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ABSTRACT

This guide is intended for use by those preparing to take the California certification examination for commercial pesticide applicators. The first chapter gives brief descriptions and illustrations of types of insect, vertebrate, plant, and microorganism pests. The other chapters cover pesticide classifications and formulations, labels and labeling, pesticide toxicity and poisoning symptoms, first aid for pesticide poisoning, how to handle pesticides, protective clothing and other safety devices, equipment and calibration, important pesticide use problems, pesticide compatibility and combinations, pesticide residues, and alternatives to pesticides. Also included is a glossary of pesticide-related words. (BB)

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PESTICIDE APPLICATION AND SAFETY TRAINING

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PESTICIDE APPLICATION AND SAFETY TRAINING

M. W. STIMMANN

Information concerning the laws and regulations pertaining to pest control, pesticide application, pesticide safety, and licensing and certification examinations may be obtained from the California Department of Food and Agriculture, 1220 N Street, Sacramento, California 95814.

The University of California's Cooperative Extension programs are available to all, without regard to race, color, or national origin.

Issued in furtherance of Cooperative Extension work, acts of May 8 and June 30, 1914, in cooperation with the United States Department of Agriculture. James B. Kendrick, Jr., Director, Cooperative Extension, University of California.

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INTRODUCTION

Recent amendments to the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) seek to expand the general knowledge of those using and applying pesticides. These amendments are designed to encourage the safe and competent use of pesticides. The law requires that pesticides be categorized into two broad groups: *general use* pesticides (available to anyone) and *restricted use* pesticides (for use only by certified applicators).

FIFRA divides applicators into two groups: *private applicators* (in general, grower-applicators) and *commercial applicators* (in general, all other applicators). FIFRA leaves to the states the responsibility for certifying applicators and, in California, the State Department of Food and Agriculture has developed a plan to certify applicators of restricted-use pesticides in accordance with the federal law.

University of California Cooperative Extension has prepared this manual and various instructional aids for those who want to study for the applicator certification examinations and for those wishing to assist others in preparing for the examination.

This manual should be used with the Environmental Protection Agency's publication, *Apply Pesticides Correctly: A guide for commercial applicators*, by those preparing for the state certification examination. In addition to the general examination, which covers laws, regulations, safety and general principles, each commercial applicator must pass a written examination on each type of pest control to be conducted. Separate training guides are available for certification in aquatic pest control, forest pest control, industrial and institutional pest control, ornamental and turfgrass pest control, right-of-way pest control, and seed treatment.

This manual will also be of value to private applicators and others who wish to expand their knowledge of pesticide use, application, and safety.

I wish to acknowledge the help of W.A. Bett, and J. Frank in the California Department of Food and Agriculture, R. G. Kuykendall in the United States Environmental Protection Agency, C.E. Crisp and P.J. Shea in the United States Forest Service, and J.B. Bailey, C.L. Elmore, C.S. Koehler, A.H. McCain, G.F. MacLeod, and J.E. Swift in the University of California Cooperative Extension.

I also wish to acknowledge some of the many sources of information used to prepare this manual. These include: *The Pesticide User's Guide* published by Colorado State University Cooperative Extension; *The Pesticide Applicator Training Manual* published by the Northeastern Regional Pesticide Coordinators; pesticide applicator training materials prepared by the University of Nevada Cooperative Extension; and "California Worker Safety Training Courses" coordinated by J.E. Swift. Special acknowledgement is hereby given to J.B. Bailey and J.E. Swift, whose *Pesticide Information and Safety Manual* was particularly helpful.

Jack Litewka, who edited and typed the manuscript and compiled the glossary of pesticide terminology, and Marv Ehrlich, who prepared the illustrations, both deserve my special acknowledgement and gratitude.

M. W. STIMMANN

Chapter 1

PESTS

In the home, the garden, on the farm, in a lake or pond, or in countless other places, we tend to favor one or a few species of plants and animals over others. In each case, the unwanted species are considered to be pests. *Pests* are organisms which attack or otherwise adversely affect our crops, bodies, homes, pets and livestock, or which compete with or attack our plants.

The first step in solving any problem is to understand what is causing the problem. Identifying a pest problem is often a simple job. Certain pests become familiar to anyone with a particular interest in a crop, commodity, ornamental or specific environment. The common pests are recognized and usually dealt with whenever they are present. But when a person is unfamiliar with a pest, or what is believed to be a pest, it is necessary to obtain a correct identification before deciding if any management or control program should be undertaken.

Failure to properly identify the pest may result in wasted time, money, chemicals and effort. Proper identification will make it possible for you to understand much more about the pest, to make appropriate selection and application of management techniques, and to minimize your control effort.

Pests can be divided into five main groups:

- Insects and their close relatives—mites, ticks, and spiders
- Snails and slugs
- Vertebrates
- Weeds
- Plant disease agents

INSECTS

Each kind of living thing is called a species—and there are over one million species of insects, which means that there are more kinds of insects than any other kind of organism. Of these million-plus species, fewer than 100,000 are found in the United States; and of these, only a few hundred are considered to be significant pests.

In California we have perhaps 100 common pest insect species: these cause an estimated $600 million in damage to the state's agricultural industry each year. Insects that are agricultural pests wreak havoc at various times. They may attack the seed before it is placed in the ground; the seedlings before they emerge; the small plants, leaves, stems, roots, buds and fruit of the mature plants; the crop at harvest; and even the harvested crop during storage.

Insects may cause damage in many ways, including:

- Direct chewing on the leaves
- Boring or tunneling into the plant leaves, stems or fruit
- Direct feeding on the fruits, nuts or berries
- Sucking plant juices from the stems, etc.
- Causing malformations such as galls on plants
- Transmitting plant diseases
- Feeding on the flesh and blood of animals and people
- Transmitting diseases of animals and people
- Feeding on stored products
- Feeding on buildings, etc.
- Causing allergic reactions among animals and people
- Causing fright and nuisance

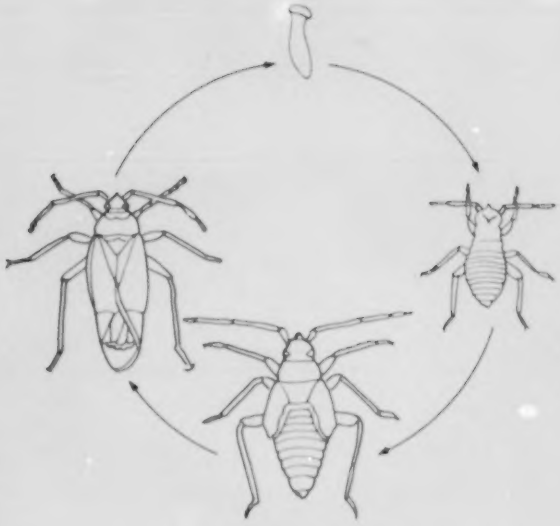
A troublesome insect must first be identified before control measures are undertaken. Insect species identification often requires the assistance of a person with highly specialized knowledge. In many cases, however, it is possible for the pesticide applicator to recognize, in general, the major group to which the insect belongs. This small amount of knowledge about the insect can help you understand important

facts about its biology, behavior, and whether it is likely to be a pest. Knowledge of the development and form of insects is a basic requirement for identification.

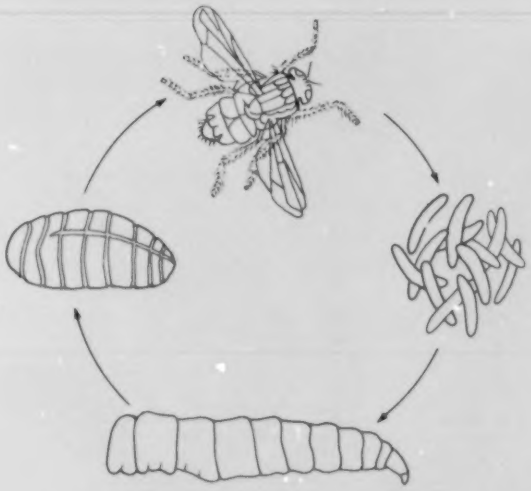
Development of Insects

Insects have complex life cycles. Each insect changes form one or more times during its life. This change of form, called *metamorphosis*, may be divided into two types—simple and complete.

Insects with simple metamorphosis hatch from eggs and appear to be miniature copies of the adult insect: these are called nymphs. As the nymphs feed and grow, they shed their skin several times—a process called molting. When they complete their development, they are full-sized adults. Many common insects have simple metamorphosis, including grasshoppers, termites, chewing lice, sucking lice, thrips, bugs, and aphids.



The more complex type of development among insects is called complete metamorphosis. This developmental pattern involves several complete changes in form during the growth of the insect. Insects with complete metamorphosis begin life as an egg. A larva hatches from this egg; the larva feeds, grows and molts several times until it becomes a mature larva. Then the larva enters an intermediate stage in which it takes on a form unlike that of the larva or the adult: in this stage it is called a pupa. The adult insect develops within the pupa and at the end of pupation, the adult insect emerges. It is the adult that mates, produces eggs, and starts the next generation. Common examples of insects with complete metamorphosis are: beetles, moths and butterflies, flies, fleas, and bees and ants.



Insect Form and Structure

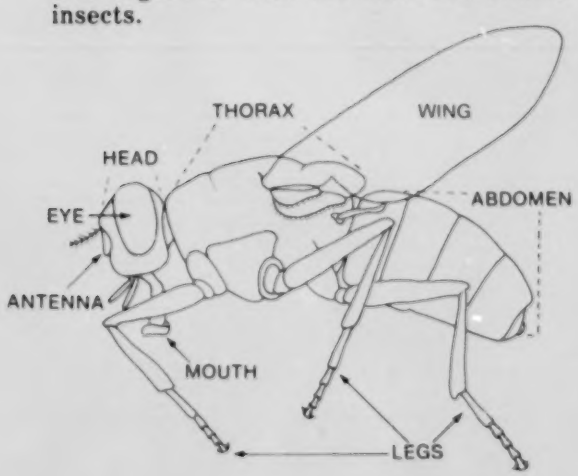
The identification of any insect depends upon understanding its form and structures. Adult insects are small animals having a segmented external skeleton, three major body regions, six jointed legs, one pair of antennae, complex mouth parts, and (frequently) two pair of wings.

The "skin" of an insect is in fact the segmented external skeleton which covers the entire body. The exoskeleton protects the insect from enemies, gives the animal considerable rigidity, and serves as the support of the soft internal body parts including the muscles, nerves, blood system and various organs and glands. The skeleton is jointed to allow the animal to move, but it cannot grow. Therefore the skeleton must be shed from time to time as the insect develops and grows.

All adult insects have three major body regions: a head, a thorax, and an abdomen. The insect head bears the sensory organs—eyes, antennae (for feelers), and mouth parts. The eyes of insects may be simple cells capable only of light detection, or they may be highly complex organs made of thousands of individual eyelets, capable of detecting movement, shapes, and colors.

The thorax of the insect bears most of the locomotory organs, including legs and wings. The legs may be highly modified for such activities as running, digging, or swimming. The wings, if present, may be simple and underdeveloped for flight, or they may be highly developed for rapid and powerful flight.

The abdomen of the insect may have varying forms, but in the adult it lacks legs or wings. It may have some feeler-like appendages on the hind end, but these are never true legs. The abdomen bears the reproductive organs of both the male and female insects.



The wings are especially important in insect identification. Adult insects usually have two pair of wings, although certain groups, such as flies, may have only one pair, and others may completely lack wings, such as silverfish and fleas. The wings may be almost featureless and transparent, like those of many flies; they may be covered with brightly colored scales, like butterflies, or they may be hardened into a tough body covering, like beetles. The number of wings and their form and ornamentation are important factors in insect identification.

Insect mouth parts are also important in identification and are as variable as the wings. The mouth parts may be modified for chewing hard seeds and grains, shaped into siphon-like tubes for sucking plant juices, developed into needle-like structures for piercing plants or flesh, or modified into sponge-like structures for lapping up liquids.

Insect Classification

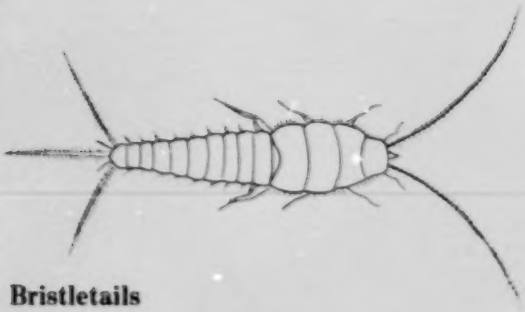
Scientists who classify living things divide animals into a number of groupings, going from the largest generally-related categories and moving to the more specific differentiations. Every animal is a member of a:

Phylum
Class
Order
Family
Genus
Species

Insects are members of the phylum Arthropoda and the class Insecta. Members of the class Insecta are all subclassified into one of about 20 orders. Examples of common orders are:

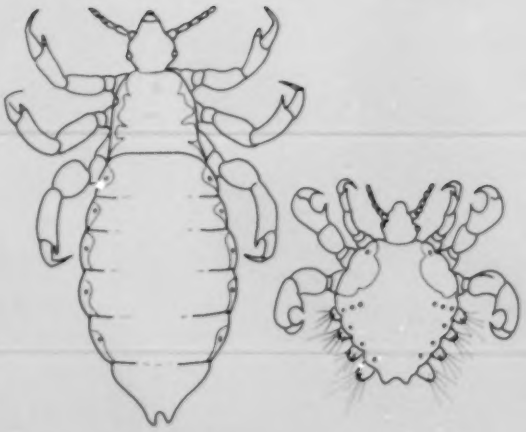
Common name	*Scientific name*
Bristletails	Thysanura
Chewing lice	Mallophaga
Sucking lice	Anoplura
Thrips	Thysanoptera
Termites	Isoptera
Grasshoppers	Orthoptera
True bugs	Hemiptera
Aphids, leafhoppers, scale insects	Homoptera
Moths, butterflies	Lepidoptera
Beetles	Coleoptera
Flies	Diptera
Wasps, bees, ants, sawflies	Hymenoptera
Fleas	Siphonaptera

For ease of understanding and to make it easier to remember the orders of insects, we will refer to them by their common names as we list identifiable characteristics of the adult insect.



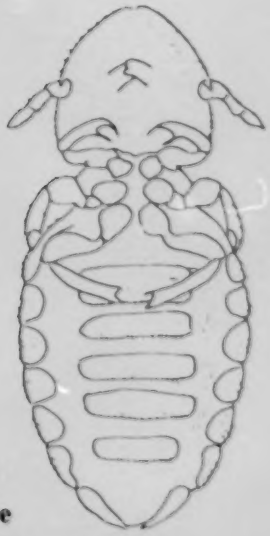
Bristletails

- No wings
- Usually two or three long tails
- Simple metamorphosis
- Often found in houses
- Feed on paper, cloth, and starches
- Are sometimes called "silverfish"



Sucking lice

- No wings
- Piercing-sucking mouth parts
- Simple metamorphosis
- Feed by sucking blood of animals and people



Chewing lice

- No wings
- Chewing mouth parts
- Broad head
- Simple metamorphosis
- Feed on birds, where they are found on skin and feathers

Thrips

- May have fringed wings, may lack wings
- Have a combination of sucking and chewing mouth parts
- Simple metamorphosis
- Usually feed in flowers or buds of plants
- Cause misshaped flowers, buds, fruits, and leaves

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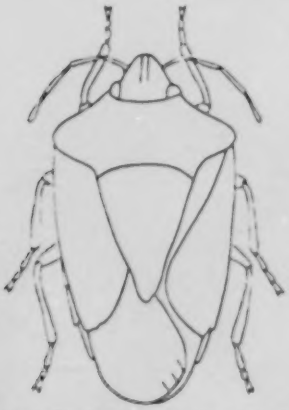
Termites

- Four wings of equal size, or no wings at all
- Chewing mouth parts
- Simple metamorphosis
- Feed on wood and wood products
- Live in complex societies

Grasshoppers, crickets, cockroaches, and katydids

- Two pair of wings, or no wings at all
- Chewing mouth parts
- Simple metamorphosis
- Pests of agriculture and the home



True bugs

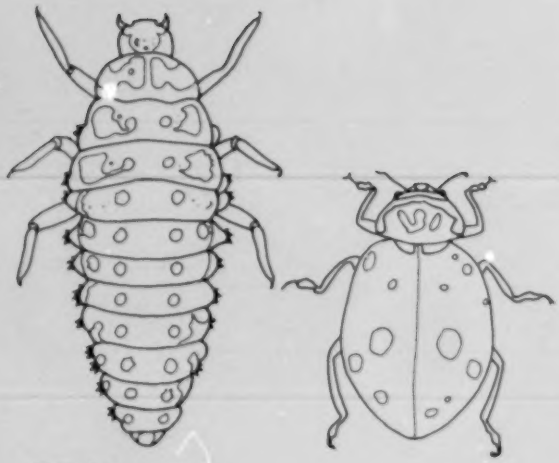
- Two pair of wings, or no wings at all
- Top pair of wings partly leathery, partly transparent
- Piercing-sucking mouth parts
- Simple metamorphosis
- Suck juices from plants and blood from animals and people

Aphids, leafhoppers, and scale insects

- May or may not have wings
- Piercing-sucking mouth parts
- Simple metamorphosis
- Suck juices from plants and carry plant diseases

Moths and butterflies

- Two pair of wings, usually with scales
- Chewing mouth parts (larvae), sucking mouth parts (adults)
- Complete metamorphosis (larvae called "caterpillars" or "worms")
- Feed on many crops, damaging leaves, stems, tubers, and fruits

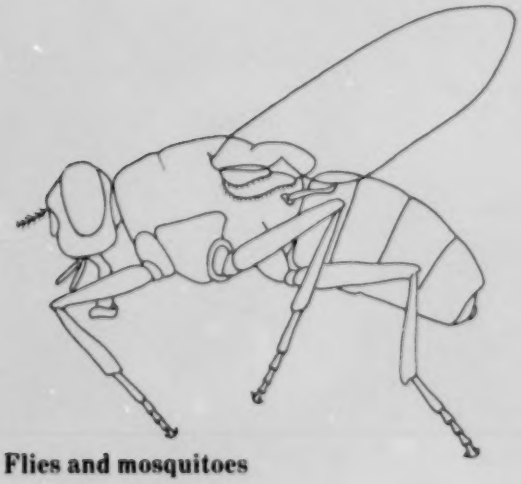


Beetles

- Two pair of wings
- Top pair of wings hard and opaque, bottom pair transparent
- Chewing mouth parts
- Complete metamorphosis
- Larvae and adults feed on plants, in soil, in wood, and many other places
- Larvae and adults may be pests

Wasps, bees, ants, and sawflies

- Two pair of wings or no wings
- Chewing mouth parts
- Adults usually have narrow waists
- Complete metamorphosis
- May have complex social organization



Flies and mosquitoes

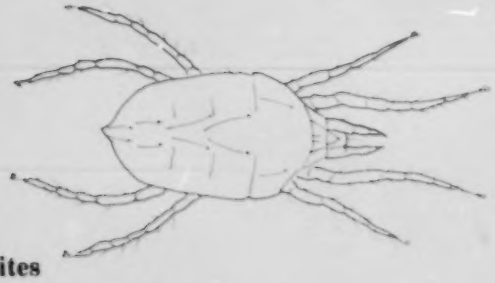
- One pair of wings
- Piercing-sucking mouth parts variously modified
- Complete metamorphosis (larvae called "maggots")
- May feed in rotting material, plant parts, or animal flesh
- May carry animal and human diseases

Fleas

- No wings
- Piercing-sucking mouth parts
- Complete metamorphosis
- Feed on blood
- May transmit animal diseases

Insect Relatives

Mites, ticks, and spiders are all related to the insects. Generally these insect relatives can be recognized by their overall appearance and by their eight jointed legs. Their bodies are divided into two major regions rather than three, and they never have wings.

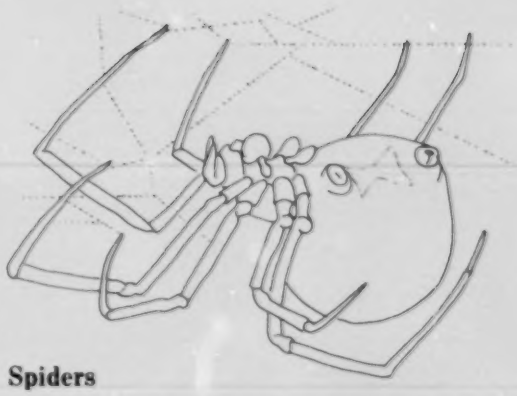


Mites

- Usually very small
- Sucking mouth parts
- Damage plants through feeding; attack animals and people by irritating skin
- May transmit plant and animal diseases

Ticks

- Leathery soft body, without distinct head
- Sucking mouth parts
- Parasitic on animals and people
- May transmit animal and human diseases



Spiders

- Fang-like sucking mouth parts
- Most are beneficial; a very few are poisonous

How to Identify an Insect

1. Compare specimens of the insect with museum specimens or with pictures.
2. Use an insect key such as those in field guides and other insect identification texts. Keys may require specialized knowledge of insects and generally do not allow the identification of individual species.
3. Contact an authority, such as a farm advisor, agricultural commissioner, or entomological expert in the USDA, Cooperative Extension, or at a college or university.

SNAILS AND SLUGS

Snails and slugs are members of the large group of animals called molluscs. They often become pests around the home garden, in lawns, in greenhouses, and in ornamental plantings. These animals may damage plants by feeding on the foliage, by their presence in the plant after harvest, and by the slime trails they make as they move from place to place on their muscular "foot."

Snails are soft animals whose bodies are protected by a characteristic coiled shell. Because of the shell, snails are able to survive in fairly dry conditions. They generally reproduce by laying eggs, and small snails are frequently found in considerable abundance.

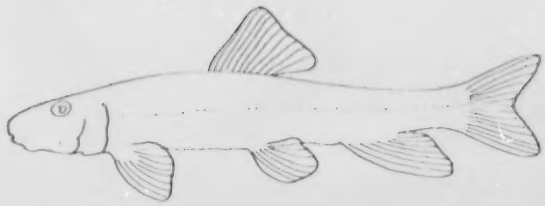
Slugs are closely related to snails, but they lack the snail's coiled shell. Without this protection, they generally require a moist, cool environment, such as in the soil, under debris, or in foliage.

VERTEBRATES

Vertebrates are animals with backbones. They include fish, frogs, toads, snakes, birds and mammals. Vertebrate pests, like weeds, are simply animals whose presence or activities are in conflict with human interests and well-being. What may be a pest animal in some situations may be a highly desirable animal in others. For example, the sea otter is a fur-bearing animal considered by some to be extremely valuable; but, because the sea otter is frequently accused of feeding on abalone, it is considered by others to be a pest.

Fish

In California most fish pests are introduced species which compete with more desirable



food and game fish. Some fish species are undesirable because they serve as intermediate hosts for parasites of animals and people.

Amphibians and Reptiles

There are no species of amphibians in California that are considered to be pests. Occasionally, toads or frogs may become nuisances around homes or parks. Most snakes are not poisonous, and they are generally beneficial. However, when people and rattlesnakes are present in the same place, there is a definite hazard. Frequently, as housing developments move into rural areas, individual rattlesnakes may invade the residential areas. Generally, controls are applied on an individual case-by-case basis.

Birds

Bird damage can be quite varied and includes structural damage by woodpeckers, destruction of feed and crops, hazards to animal and human health, and annoyance caused by birds roosting near dwellings.

In California we have a great many species of birds, most of which are beneficial and fully protected by law. A few species, however, are considered to be pests and are not protected, or they are regulated so that they may be managed when necessary. Some of our pest birds are linnets, horned larks, crowned sparrows and blackbirds, cowbirds, starlings, and occasionally, woodpeckers.

Control of bird pests requires highly specialized knowledge and techniques. And since birds are protected by state and federal laws and regulations, you should contact your county agricultural commissioner before you undertake any bird control program.

Mammals

All mammals have warm blood, fur, and feed their young milk. Some mammal pests

cause serious health problems when they carry diseases like rabies, plague, or tularemia. Other mammals are pests because they feed on crops or because they damage structures like buildings, ditches, and dams. Pest mammals may also damage gardens, lawns, household goods, or stored food products.

WEEDS

A weed is simply a plant growing where it is not wanted. Weeds are damaging because they may:

- Compete with other plants for water and nutrients, resulting in reduced crop yields and impaired crop quality
- Increase production costs
- Cause irritation and poisoning
- Serve as reservoirs of insects and plant diseases
- Reduce water flow in irrigation systems

There are more than 500 species of plants in California that may cause such problems. A successful weed control method depends upon identifying the weed, which in turn often requires the help of a specialist.

Common Forms of Weeds

While there are a great many species of weeds, most may be placed into one of two convenient groups.

Narrowleaved weeds include grasses, sedges, rushes, cattails, and a few others. The nar-

rowleaved weeds generally have parallel veins in the leaves.

Broadleaved weeds include most other weeds, such as the willows, oaks, mustards, dock, pigweed, purslane, and bindweed. These weeds may be recognized by the presence of a net-like pattern of veins in the leaves.

Common Life Cycles of Weeds

Plants can be classified according to their life cycles as annuals, biennials, or perennials. These are not strict botanical divisions, but groupings that are important in determining how to control the plants.

Annuals mature in one season and are propagated by seed. **Summer annuals** grow from seeds which sprout in the spring, mature, and reproduce before dying in the winter. Among the common summer annuals are barnyard grass, punctureVine,

Russian thistle, and pigweed. Winter annuals germinate in the fall or winter and grow until spring when they flower, produce seed and die. Among the common winter annuals

are chickweed, mustard, wild oats, and annual bluegrass.

Biennials require two years to develop and complete their life cycles. These plants grow vegetatively (without flowering) through

the first year; in the second year, the plant flowers, produces seed and generally dies. Common biennials are purple starthistle, milk thistle, mullein, and bristly oxtongue.

Perennials are plants that live three years or longer. These plants flower and set seed

without dying. They live indefinitely; they may lose their foliage during the winter and die back to the ground, but they recover in the spring. Common examples are Johnsongrass, field bindweed, dandelion, plantain, willow, and poison oak.

Perennial plants are members of many major plant groups, and they may take many forms. Some are herbaceous soft-bodied plants, others are shrubs, and some are fully developed woody trees. Many perennials can store food underground in rhizomes, bulbs, or tubers, which makes these plants difficult to kill by mechanical or chemical means.

How to Identify a Weed

1. Compare specimens of the weed with dried specimens from a museum or with pictures.
2. Use a weed key such as those in field guides and other texts. Keys may require specialized knowledge of weeds.
3. Contact an authority, such as a farm advisor, agricultural commissioner, or weed scientist in the USDA, Cooperative Extension, or at a college or university.

PLANT DISEASES

A plant disease is any harmful condition that makes a plant different from a normal plant in appearance or function. Diseased plants exhibit some malfunction or abnormality in their development and they often look unhealthy.

Symptoms of Plant Diseases

Diseased plants may form swellings, galls, leaf curls, or other types of overdevelopment of tissues. Or the plants may be stunted, lack chlorophyll, or fail to develop some organ, or their tissues may die, showing blights, leaf spots, wilting, or cankers.

Non-parasitic Plant Diseases

Plant diseases may result from such factors as unfavorable growing conditions, nutrient deficiency, extremes of weather, and toxic chemicals including air pollution, pesticides, salts, and excessive fertilizer. Diseases caused by such conditions cannot be passed from one plant to another.

Parasitic Plant Diseases

Plant diseases may also result from the effects of living agents. These parasitic plant diseases are caused by fungi, bacteria, viruses, mycoplasmas, nematodes, or parasitic plants.

The development of a parasitic plant disease depends on the life cycle of the parasite, which depends in turn upon the temperature and moisture of the environment. An infection begins with inoculation, that is, when the infectious agent enters the plant. The parasites then develop in the plant until symptoms begin to show, at which time the plant may be recognized as being diseased.

Fungi are the largest group of plant pathogens. This group of organisms includes mushrooms, molds, and yeasts. These are simple plants which live on other living organisms, or in decaying organic material, because they lack chlorophyll with which to manufacture their own food. Some fungi are found on the skin of animals and humans, inside of insects, and in or on plants. It is the fungi which live on other plants that are most frequently of interest to the pesticide applicator.

Fungi reproduce by means of spores which spread the disease when they move from one host to another. The plant parasitic fungi are also transmitted from one plant to another through mechanical means. Movement of plants, plant parts, and soil from one area to another may also spread the disease.

Some examples of fungi-caused plant diseases are rusts, smuts, powdery mildews, downy mildews, and scabs.

Bacteria cause some major diseases of plants. These parasites are microscopic, one-celled organisms that lack chlorophyll and require an external source of organic matter for their food. Bacteria reproduce by cell division, and generally enter a host plant through natural openings or through

wounds. Bacteria often are transmitted from plant to plant by the activity of people, by contaminated equipment, by wind and rain, or by insects.

Common bacterial diseases are canker of stone fruits, walnut blight, crown gall, fire blight, and bacterial wilt of beans.

Viruses are extremely small living things that cannot be seen with an ordinary light microscope. They cannot grow outside the cells of the living host. The viruses are transmitted by mechanical means during pruning or harvesting, or by insects, mites, nematodes, or fungi. Once introduced into the host plant, the virus may cause visible symptoms, although some viruses are symptomless.

Common types of virus-caused plant diseases are mosaics, yellows, curly top, ringspots, and stunt. The viruses themselves are generally named for a common host and the symptoms they cause; for example, cucumber mosaic virus, prunus ringspot, sugar beet curly top, and lettuce mosaic are all important plant viruses.

Mycoplasma-like organisms, which are intermediate in size between bacteria and viruses, have recently been discovered to be the cause of many plant diseases formerly attributed to viruses. These diseases are transmitted by insects.

Included among the mycoplasma-like plant diseases are pear decline, aster yellows, western-X disease of peach, and citrus stubborn disease.

Nematodes are members of a group of animals known as roundworms, threadworms, and eelworms. They are generally elongate, cylindrical animals tapering at the two ends. They may be free-living, parasitic in insects and other invertebrates, parasitic in animals and people, or parasitic in plants. Those which are parasitic in plants may attack either the stem or foliar parts, or they may live in the roots and tubers. The nematodes feed on plants by puncturing the plant cells with their hollow feeding tube and sucking the cell contents. The worms reproduce by laying eggs, and during development they pass through several larval stages. Nematodes are frequently transported from place to place along with soil, plants, and plant parts.

Common nematode-caused plant diseases include root knot nematodes, cyst nematodes, root lesion nematodes, and seed and leafgall nematodes.

Parasitic seed plants include the mistletoes, which may be found growing on the stems and branches of trees and shrubs, and the dodders, which form tangled masses of yellow, orange, or purple foliage as they grow over their host plants. Dodder is a common pest on alfalfa, sugar beets, tomatoes, and other crops.

How to Identify a Plant Disease

Some plant diseases can be identified by simple visual inspection of the plants, but in many cases accurate identification requires considerable training and experience.

In other cases it is necessary to submit the diseased plants to an authority for examination. If possible, the entire plant should be submitted with protection from high temperatures and lack of moisture. A letter explaining the details of the problem should be attached.

Chapter 2

PESTICIDE CLASSIFICATIONS AND FORMULATIONS

Pesticides are defined as (1) substances or mixtures of substances intended for controlling, preventing, destroying, repelling or mitigating any form of life declared to be a pest; and (2) any substance or mixture of substances intended for use as an insect or plant growth regulator. Insecticides, herbicides, defoliants, dessicants, fungicides, nematicides, and rodenticides are some of the many kinds of pesticides. The definition of pesticide is not limited to any particular kind of chemical.

CLASSIFICATION OF PESTICIDES

Pesticides may be classified in a number of ways, depending on our particular interest at the moment. Following are brief descriptions of some commonly used classification systems.

By Chemical Nature

Most common pesticides can be classified into two main chemical groups: the inorganic and organic compounds. The *inorganic* pesticides are those made of chemicals which do not contain carbon. These materials are usually crystalline, salt-like in appearance, and stable. Usually they are soluble in water. *Organic* pesticides are compounds which contain carbon. These constitute the majority of all modern pesticides. In addition to carbon, they contain hydrogen and often oxygen, nitrogen, phosphorous, or sulfur in the molecule. Their appearance is variable, and they are usually insoluble in water. Hundreds of organic pesticides have been marketed, and they are subclassified into several major groups.

By Target Pest Species

Pesticides are sometimes classified by the target species. An example of this sort of classification is :

Pesticide	*Target Pest*
acaricide	mites, ticks
algaecide	algae
attractant	insects, birds
avicide	birds
bactericide	bacteria
defoliant	unwanted plant leaf
dessicant	plants requiring dehydration
fungicide	fungi
growth regulators	insect and plant growth
herbicide	weeds
insecticide	insects
miticide	mites
molluscicide	snails, slugs
nematicide	nematodes
piscicide	fish
predacide	vertebrates
rodenticide	rodents
silvicide	woody vegetation

Because insecticides and herbicides are by far the most widely used pesticides, it is worthwhile to examine them in some detail.

CLASSIFICATION OF INSECTICIDES

By Chemical Group

Clorinated hydrocarbons (or organochlorines) are perhaps the most familiar group of synthetic organic insecticides. In the recent past they were by far the most common insecticide available. Common examples are DDT, BHC, lindane, methoxychlor, chlordane, aldrin, heptachlor, toxaphene, and endrin. Some of these have been banned or severely restricted.

Organophosphates are the second major group of insecticides. Members of this group contain phosphorous in the molecule. Common examples are parathion, dimethoate, naled, malathion, phorate, and diazinon. From a human safety standpoint, organophosphates are the most important group of pesticides and cause the greatest number of pesticide-related illnesses each year.

Carbamates are the third major group of insecticide chemicals. These chemicals contain nitrogen in the molecule and include such common insecticides as aldicarb, carbaryl, carbofuran, and methomyl. Members of this group, like the organophosphates, frequently cause human pesticide poisoning.

Natural organics are a fourth group of insecticide chemicals which includes botanicals, microbials, and oils. The *botanicals* were originally obtained from plants. Included in this group are the pyrethrums extracted from chrysanthemums and nicotine extracted from tobacco. Recently certain botanicals have been prepared synthetically and are commercially available. While the botanicals are important insecticides, they are not used as frequently as are the synthetic organic insecticides.

Microbial pesticides are those whose active ingredient is a bacteria, virus, or some other microorganism. One microbial pesticide is made from the bacteria *Bacillus thuringiensis*, and is used as an insecticide on many vegetables and trees.

Petroleum oils are refined from crude oil and are used as insecticides or as herbicides. When formulated as insecticides they may be applied without dilution, or they may be mixed with an emulsifier and applied in water.

By Mode of Action

Insecticides are most easily classified according to the several ways they enter or affect the bodies of insects. Once on or within the pest, the chemical may act on one or more of the life processes. The result may be death, illness, or a change in the behavior of the insect.

Stomach toxicants enter the insect's body through the mouth and digestive tract where they are absorbed into the insect's body. Stomach poisons are acquired during feeding: Some poisons are deposited on the outside of the host, for example, on a leaf, while others are systemic, that is, they are carried in the blood or sap of the host.

Contact toxicants generally enter the insect's body as a result of contact with treated surfaces such as leaves. Like most insecticides, these poisons act upon the nerve and respiratory centers of the insect.

Fumigants are volatile and generally enter the insect's body in a gaseous phase through the respiratory system.

Systemic toxicants are applied to leaves, stems, fruit, or to the roots and are absorbed by the plant. Once inside the plant, systemic insecticides move through the plant's system to other untreated parts of the plant. The insect then acquires the *translocated* pesticide during feeding. Systemic toxicants are also used on pets and livestock.

Suffocation action results from applying materials, usually oils, which clog the breathing mechanism of the insect.

CLASSIFICATION OF HERBICIDES

By Chemical Group

Devising a simple classification scheme for herbicides is difficult because many kinds of chemicals are used as herbicides, and, while they are formulated in ways similar to the insecticides, they exhibit a variety of modes of action. To classify herbicides by chemical group requires at least 20 different categories, only a few of which will be mentioned here.

Inorganic herbicides are chemical compounds which do not contain carbon. The inorganics include such common materials as salt, copper sulfate, sulfuric acid, and sodium chlorate. These herbicides are extremely persistent and have caused serious

soil pollution problems in some areas. Many are restricted materials.

Organic herbicides may be divided into two major groups—the petroleum oils and the synthetic organic herbicides. The *petroleum oils*, refined from crude oil, can be used as either herbicides or insecticides. When formulated as herbicides, they are applied without dilution.

Synthetic organic herbicides are made up of carbon, hydrogen, often nitrogen, and other elements. Included among the common synthetic organic herbicides are 2,4-D, paraquat and DNBP.

By Use

Herbicides may be conveniently classified by use, that is, whether they are applied to the soil or foliage, and by their selectivity, that is, how they affect the target plant. (Herbicides may also be classified according to their modes of action, although this classification scheme is used infrequently.)

Selective herbicides are used to control certain weed species without injuring desirable plants. Even the best herbicides are only relatively selective and can damage or kill the desired plants as well as the weeds, if misused.

Foliage-applied selective herbicides are applied to the leaves and other above-ground parts of the plant. Once applied they may kill only the parts of the plant actually sprayed. In this case they are considered *contact herbicides*. Complete weed kill using contact herbicides requires well-directed and properly applied sprays. Complete coverage of the weed is a must. Selectivity often depends upon differences in coverage when spraying: for example, some herbicide formulations wet broad-leaved plants and run off on grasses.

Translocated herbicides are applied to the leaves and move systemically into the other parts of the plants, causing complete kill. Selectivity of the translocated herbicides depends on differences in the biochemistry of plant species; some plants are poisoned and others are not.

Soil-applied selective herbicides are applied to the ground and may be recommended for use for pre-plant, pre-emergence, post-emergence, or other treatments. These herbicides are generally incorporated into the soil by mechanical means such as discing or by water from irrigation.

Non-selective herbicides kill most plants when applied. These herbicides are used where complete removal of vegetation is desired, such as along highway rights-of-way. Non-selective herbicides can be applied to foliage as contact herbicides or as translocated herbicides. They may also be applied to soils where they kill nearly all plants growing there. Some soil-applied herbicides are available as fumigants.

PESTICIDE CLASSIFICATION BY FORMULATION

Pesticides are available in a variety of forms and may be classified on the basis of these forms. Active pesticide chemicals are frequently in a form which is not suitable for direct application. The *active ingredient* (actual pesticidal chemical) may require mixing with one or more other chemicals in order to make it satisfactory for use in controlling pests. The process of preparing mixtures of active ingredients and other materials is known as *formulation*. In formulating a pesticide, the active ingredient is made ready for use by mixing with liquid or dry diluents, grinding, or by the addition of emulsifiers, stabilizers, or other substances. The product which results from the process of formulation is also known as the *formulation*. It is the formulated product which you put into the spray tank and mix with water. Pesticides are formulated to make them easy to handle, to increase their efficiency, and to make them less hazardous to people and the environment. Some of the most commonly used formulations are:

Emulsifiable Concentrate (EC or E)

Some chemicals are often insoluble in water; by dissolving the technical material in a petroleum-based solvent, a concentrated

liquid is formed. The emulsifying agent allows the pesticide to be further diluted with water for application. Principal uses: ECs may be used on fruits, vegetables, and farm animals as well as structural pests.

Wettable Powder (WP or W)

These dispersible powders are finely ground, dry powders consisting of active ingredient and other ingredients. The wettable powders are intended for dispersion or suspension in a liquid, usually water, for application by spray equipment. They are generally mixed with water to form a slurry before being added to the mix tank. They require agitation. Principal uses: WPs can be used for most pest problems and in most spray equipment; often applied to fruits, vegetables, and other crops.

Soluble Powder (SP)

These powders are similar to wettable powders, except that the active ingredient, as well as the diluent and formulating ingredients, will completely dissolve in water. Principal uses: similar to those for the wettable powders.

Dusts (D)

Pesticides prepared as dusts consist of a finely ground carrier material containing the active ingredient. Dust formulations are intended for direct application without further mixing. Herbicides are not formulated as dusts because of the drift hazard. Principal uses: dusts are used for spot treatments and small areas of home gardens; not used much for large scale applications other than sulfur on grapes because of the drift hazard; can be used to control parasites on farm animals.

Granules (G)

In a granulated formulation, the active ingredient is mixed with an inert carrier to form particles about the size of granulated sugar. Granular formulations are intended for direct application without further dilution. They may be applied in combination with fertilizers or from the air when drift of other formulations is a problem. Principal uses: soil treatment to control pests living in soil.

Fumigants

These are volatile chemicals which become liquid when stored under pressure and which are used in confined spaces or in soil. When applied they form a gas which will destroy pest organisms. Principal uses: insect pest control in stored grain and as a soil treatment to control nematodes, many weeds, and fungi; also used to control structural pests.

Baits (B)

Active ingredients are mixed with a pest food or attractant. Principal uses: control of household pests such as ants, mice, rats, roaches, and flies; used outdoors to control birds, ants, slugs, snails, and agricultural pests such as crickets and grasshoppers.

Aerosols (A)

Aerosols, or "bug bombs," are pressurized cans which contain a small amount of pesticide that is driven through a small nozzle under pressure from an inert gas. Principal uses: aerosols are often used in households and by licensed pest control operators; some are designed for use against weeds, others for fly control, and others for greenhouse pest control; they are also used in structural pest control.

Flowables (F or L)

The flowable liquid usually is mixed with water for use in a sprayer. It forms a suspension in water which requires continual agitation. Principal uses: similar to emulsifiable concentrates.

Water-Soluble Concentrate (WS)

These liquid formulations form true solutions in water and require no agitation once mixed. Principal uses: similar to emulsifiable concentrates.

Ultra low Volume (ULV)

This highly concentrated solution may contain the active ingredient alone; it is applied without diluting. These solutions require special equipment to apply them at ultra low volumes.

Encapsulated Material

The active ingredient is encased in an inert material for a slow, sustained pesticidal release, resulting in decreased hazard.

Chapter 3

LABELS AND LABELING

THE LABEL IS A TOOL— LEARN TO USE IT

Information on pesticide labels has been called the most expensive literature available. The research and development that lead to the wording on a label frequently cost millions of dollars. The combined knowledge of laboratory and field scientists, including chemists, toxicologists, pharmacologists, pathologists, and others in industry, universities, and government, has been used to develop the information found on each registered pesticide label.

The importance of reading the label cannot be stressed too often. The information that appears on the label is put there for your knowledge and your protection. If it is read and understood and if all the directions are followed, the likelihood of misusing the material or of having an accident with the pesticide is remote. This is why we so often stress that the "most important few minutes in pest control is the time spent in ***reading the label.***

LABELS AND LABELING

First, some definitions of the terms "label" and "labeling." *Label* refers to the printed material attached to the pesticide container or the wrapper of the retail package. *Labeling* refers to all of the printed instructions that come with the pesticide. This definition includes the label on the product, the brochures and flyers provided by the manufacturer, and other information, such as handouts, from the dealer. In all cases the label and other labeling are legal documents which must follow prescribed form and whose directions must be followed by anyone using the pesticide. There are both civil and criminal penalties for using a pesticide in a manner which conflicts with the labeling.

WHEN YOU SHOULD READ THE LABEL

The pesticide label is designed to provide you with useful and important information which will allow you to use the pesticide legally, safely, and efficiently. However, the label is worthless if you fail to read all of it. There are four times when you should read the label.

1. BEFORE YOU BUY THE PESTICIDE, read the label to determine: if it is the proper chemical for your job; if the pesticide requires special equipment or application techniques (which you may not have or know); and if you must have special qualifications to use the pesticide. ***Remember:*** do not buy the pesticide on the basis of reading only the brand name. Manufacturers change products and formulations without changing brand names . . . you may not be buying what you think.
2. BEFORE YOU MIX AND APPLY THE PESTICIDE, read the label to determine: how to mix the pesticide and how much to mix; what protective clothing and equipment is required; and what first aid procedures may be required in case of accidental exposure. Also determine from the label: when to apply the material; how to apply it; the rate of application; and any residue and re-entry restrictions or disposal of crop residue restrictions which apply to its use.
3. BEFORE YOU STORE THE PESTICIDE, read the label to learn how to store your pesticide correctly. Pesticides should never be stored with food or feed. Many pesticides should not be stored where they may become contaminated by other pesticides. The label will tell you if there are any special storage precautions to follow.

4. BEFORE YOU DISPOSE OF UNWANTED PESTICIDE OR THE CONTAINER, read the label for instructions about the proper procedure for disposing of excess pesticide in order to avoid health risks or unwanted environmental contamination. Also read the label for information about the proper procedure for decontamination and disposal of the pesticide container.

HISTORY OF THE PESTICIDE LABEL

In the recent past, labels were not standardized. They were designed by each manufacturer or formulator and were often more of an advertisement than a complete source of scientifically developed information. Many labels were difficult to read and understand, and frequently they lacked critical information. Many of the non-standardized labels are still found on pesticide containers. However, after October 1977 all pesticide manufacturers will be required to label their packages in accordance with new regulations.

STANDARDIZED PESTICIDE LABELS

The new pesticide labels will conform to a set of standards as established in FIFRA. Each registered label is required to have a specific format and must contain the following information.

- Brand name. This is the manufacturer's name for the product. An example of a brand name might be DE PESTO or DE WEED or BUGOFF. This name is usually the largest and most conspicuous wording on the label, and it is the brand name which is used in most of the manufacturer's advertising.
- Common name. Most pesticide chemicals have an official common name assigned to the active ingredient. This is a generic name and may be found on the label of many brands if each contains the same toxic chemical.
- Type of formulation. The formulation of the pesticide refers to the way the active ingredient is mixed with other inert ingredients to make it ready for use by the applicator.
- Ingredient statement. All of the active (toxic) ingredients in a pesticide formulation must be listed on the label. These are given as percentages by weight. The inactive (inert) ingredients are not required to be listed by chemical name if the label shows what percentage of the total material is inert ingredient.
- Net contents. The label will tell you how much material is in the container. This will be listed in the largest possible customary unit. For example, a container might contain 5 gallons of liquid or 25 pounds of powder.
- Name and address of manufacturer. Each pesticide label must include the name of the company manufacturing and distributing the pesticide.
- EPA registration number and establishment number. The EPA registration number on the label indicates that the product has been registered with the Environmental Protection Agency. The EPA establishment number indicates the particular manufacturing plant at which the pesticide was made.
- Statement of use classification. After October 1977 each pesticide offered for sale in the United States must have a statement of use classification included on the label. Pesticides are to be classified for general use or restricted use. *General use* pesticides are the least hazardous materials. They offer little danger to persons or the environment when used in accordance with the label directions. These pesticides will be available for use by anyone. *Restricted use* pesticides are those which may be hazardous to the environment, the applicator, or other persons, even when label directions are followed. The restricted use pesti-

PRECAUTIONARY STATEMENTS

HAZARDS TO HUMANS AND DOMESTIC ANIMALS

DANGER

Fatal if swallowed, inhaled or absorbed through the eye. Do not get in eyes or on clothing. Wear goggles or face shield when handling. Avoid contact with skin. Do not breathe dust or spray mist. Wear a pesticide respirator jointly approved by the Mining Enforcement and Safety Administration (formerly the U.S. Bureau of Mines) and by the National Institute for Occupational Safety Health. Wash thoroughly after handling. Remove and wash contaminated clothing before reuse.

ENVIRONMENTAL HAZARDS

This pesticide is toxic to wildlife and fish. Use with care when applying in areas frequented by wildlife or adjacent to any body of water. Keep out of lakes, streams, or ponds. Do not apply when weather conditions favor drift from target area.

BENEFICIAL INSECT CAUTION

This pesticide is highly toxic to bees exposed to direct treatment or to residues remaining on the treated area. Do not apply when bees are actively visiting the crop, cover crop, or weeds blooming in the treated area. Applications should be timed to provide the maximum possible interval between treatment and the next period of bee activity.

PHYSICAL OR CHEMICAL HAZARDS

Flammable! Keep away from heat and open flame.

DIRECTIONS FOR USE

It is a violation of federal law to use this product in a manner inconsistent with its labeling.

RE-ENTRY STATEMENT

Do not treat areas where unprotected humans or domestic animals are present. Do not allow entry into treated fields within 48 hours of treatment, unless full protective clothing is worn. Consult appropriate state regulatory officials for State Re-Entry Restrictions which take precedence if more restrictive than those stated on this label.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage, disposal or cleaning of equipment. Pesticide, spray mixture, or rinsate that cannot be used or chemically processed should be disposed of in a landfill approved for pesticides or buried in a safe place away from water supplies. Triple rinse (or equivalent) and dispose in an incinerator or landfill approved for pesticide containers, or bury in a safe place. Consult federal, state or local disposal authorities for approved alternative procedures.

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RESTRICTED USE PESTICIDE

FOR RETAIL SALE TO AND APPLICATION ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION

DE PESTO

INSECTICIDE

FLOWABLE CONCENTRATE

ACTIVE INGREDIENT:	
Pestoff *(trisalicylic-2, 5-dichlorocarbamate)*	43.8%
INERT INGREDIENTS:	56.2%
TOTAL:	100.0%

THIS PRODUCT CONTAINS 4.0 LBS OF PESTOFF PER GALLON

KEEP OUT OF REACH OF CHILDREN

DANGER—POISON

STATEMENT OF PRACTICAL TREATMENT

IF SWALLOWED—Drink 1 or 2 glasses of water and induce vomiting by touching the back of throat. Do not give anything by mouth to an unconscious person. Get medical attention.

IF ON SKIN—In case of contact, remove contaminated clothing and immediately wash skin with soap and water. Get medical attention.

IF INHALED—Remove to fresh air. If not breathing, give artificial respiration, preferably mouth-to-mouth. Get medical attention.

IF IN EYES—Immediately flush eyes with plenty of water for at least 15 minutes. Get medical attention.

NOTE TO PHYSICIAN—Pestoff is a cholinesterase inhibitor. Atropine is antidotal.

SEE SIDE PANEL FOR ADDITIONAL PRECAUTIONARY STATEMENTS

A-Z

A-Z Chemicals, Inc.
Chemcity, Minnesota 55888

EPA Registration No. 102357-42
EPA Est. 102357-MN-1

NET CONTENTS ONE GALLON

DIRECTIONS FOR USE CONTINUED

METHODS OF APPLICATION: The minimum gallonage requirement is 10 gallons of finished spray per acre with ground equipment, 2 gallons per acre with aircraft.

ALFALFA: Air and Ground Application—Alfalfa Weevil Larvae, Egyptian Alfalfa Weevil Larvae, Pea Aphid, and in New York state for Snout Beetle control. Apply the amount of De Pesto indicated in the chart, when feeding is noticed or when insects appear. Alfalfa Weevil Adult—Apply 1-2 pints per acre when insects appear. Lygus Bugs—Apply 2 pints per acre prior to bloom. Observe the indicated number of days after application before cutting or grazing. Do not apply more than once per season. Apply only to field planted to pure stands of Alfalfa. For waterfowl protection, do not apply to fields in proximity of waterfowl nesting areas or areas where waterfowl repeatedly feed.

Pints of De Pesto Per Acre	Do Not Cut or Graze Within
½	7 days
1	14 days
2	28 days

CORN, FIELD: Ground Application—Corn Rootworms—Use 1½ pints of De Pesto per 13,000 linear feet (1 acre with 40 inch spacing). Apply, at planting, as a 7 inch band over the row or inject on each side of the row by mixing with water or liquid fertilizers. When De Pesto is used with liquid fertilizers, mix in the following way making sure that the mixture is physically compatible. Premix 1 part of De Pesto with 2 parts of water. Add this premix to the tank of fertilizer along with rinsings from the premixing container. Maintain agitation in the tank after mixing and during application. Do not mix until ready to use.

SUGARCANE: Sugarcane Borer—Apply 1-1½ pints De Pesto per acre using aerial equipment. Check sugarcane fields weekly, beginning in early June and continuing through August. Make first application only after visible joints form and 5% or more of the plants are infested with young larvae feeding in or under the leaf sheath and which have not bored into the stalks. Repeat whenever field checks indicate the infestation exceeds 5%. Do not apply within 17 days of harvest. Do not use in Hawaii.

ORANGES, LEMONS, GRAPEFRUIT, and TANGELOS in Arizona and California: Air and Ground application—Citrus thrips—Apply De Pesto at ½ to 1 pt. per acre. Use sufficient water to obtain thorough coverage (5 to 15 gals./acre by air). Use the higher rate on severe infestations of thrips. Apply in the early spring before bloom when the new growth is about 3 to 4 inches long. Make additional applications as needed until the new fruit is walnut size. Application at petal fall may be critical to prevent fruit scarring. Applications during mid-summer to protect new growth on young trees are also recommended. Do not apply within 3 days of harvest. Do not graze livestock in treated orchards for 10 days after treatment.

POTATO: Tuberworm, cabbage looper, aphids, and in areas east of the Mississippi River, leafhoppers and flea beetles. Apply De Pesto at indicated rates when field checks indicate the insect infestation is above 5%. Tuberworm, cabbage looper and aphid—apply ½ to 1 pt. per acre. Leafhopper and flea beetles—apply ½ pt. per acre. Do not apply within 14 days of harvest.

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DIRECTIONS FOR USE

General Classification

It is a violation of Federal law to use this product in a manner inconsistent with its labeling.

De Weed is for weed control in certain crops, ornamental plantings, on industrial sites, and around the farm. It should be applied before weeds emerge or following removal of weed growth. It controls a wide variety of annual broadleaf and grass weeds when used at selective rates in agricultural crops and ornamental plantings. When used at higher, non-selective rates in non-crop areas, it also controls many perennial broadleaf and grass weeds.

GROUND APPLICATION Use conventional spray equipment with 80° flat fan nozzles. Screens in spray system should be no finer than 50 mesh. Use a pump with capacity to maintain 35-40 psi at nozzles. Use hydraulic or mechanical agitation during mixing and application to maintain a uniform suspension. **Aerial application:** Use only where specified in the use directions.

BLUEBERRIES AND CANEBERRIES (blackberries, boysenberries, loganberries, raspberries) Quackgrass. Apply 5 lbs. per acre in the fall or split the application, applying 2½ lbs. per acre in the fall plus 2½ lbs. per acre in the spring, when quackgrass is growing. Do not apply when fruit is present.

ALFALFA Pure alfalfa less than one year old (Northeastern U.S. only)—Henbit, wild mustard, chickweed, alyssum, downy brome, wild oats, and pigweed. Pure alfalfa which has been seeded in the spring (before June 1) may be treated in the fall after the last cutting but before frozen ground conditions. Apply 1 lb. of De Weed per acre. For ground application apply in a minimum of 2½ gals. of water per acre.

GRASSES GROWN FOR SEED (Pacific Northwest only)—Perennial ryegrass, tall fescue and fine fescues, such as Pennlawn, Chewings, Ranier, and related species. Control of broadleaf weeds and annual grasses including annual ryegrass, rattail fescue, silver hairgrass and downy brome. Apply 2½ lbs. of De Weed in a minimum of 15 gals. of water per acre as soon as fall rains start. Apply only to grasses from which at least one seed crop has been cut.

WEED CONTROL on industrial sites, highway medians, and shoulders, railroad rights of way, lumber yards, and in non-crop areas on farms such as around buildings, fuel storage areas, along fences, roadsides, and lanes. Aerial application may be made where it is feasible. Use at least 1 gal. of water for each 1 lb. of De Weed. Use more water if practical for both ground and aerial application. To control annual broadleaf and grass weeds (including barnyard grass, cheat, crabgrass, lambsquarters, foxtail, ragweed, puncturevine and mullein), apply 6-12½ lbs. per acre. To control most annual and many perennial broadleaf and grass weeds (including quackgrass, bluegrass, redtop, burdock, Canada thistle, orchardgrass, dogfennel, and plantain), apply 12½-25 lbs. per acre. To control hard-to-kill perennial weeds (including bull thistle and sow thistle), apply 25-50 lbs. per acre.

STORAGE AND DISPOSAL

Do not contaminate water, food or feed by storage, disposal or cleaning of equipment. Open dumping is prohibited. Pesticide, spray mixture, or rinsate that cannot be used or chemically reprocessed should be disposed of in a landfill approved for pesticides or buried in a safe place away from water supplies. Containers should be disposed of in an incinerator or landfill approved for pesticide containers, or buried in a safe place. Consult Federal, State, or local disposal authorities for approved alternate procedures such as limited open burning.

DE WEED

HERBICIDE
WETTABLE POWDER

ACTIVE INGREDIENT: weed out *(triazoic acid)*	80.0%
INERT INGREDIENTS:	20.0%
TOTAL:	100.0%

KEEP OUT OF REACH OF CHILDREN

CAUTION

STATEMENT OF PRACTICAL TREATMENT

In case of contact, wash skin with plenty of soap and water. Get medical attention if irritation persists.

PRECAUTIONARY
STATEMENTS

Hazard to Humans
and Domestic Animals

Harmful if swallowed, inhaled, or absorbed through the skin. Avoid breathing dust or spray mist. Avoid contact with skin, eyes, or clothing. Wash thoroughly after handling. Remove and wash contaminated clothing before reuse.

Environmental Hazards

Keep out of lakes, streams, or ponds. Do not apply when weather conditions favor drifts from target area.

A-Z
A-Z Chemicals, Inc.
Chemcity, Minnesota 55888

EPA Reg. No. 102357-41
EPA Est. 102357-MN-1

Net Weight 5 Pounds

cides are to be used only by certified applicators. They will not be available to non-certified persons.

- Signal words and symbols. Human hazards are indicated on the label through the use of toxicity-category signal words and the skull and cross bones symbol. Each pesticide formulation is assigned to a toxicity category depending on how hazardous it is to human health. The categories have been determined by considering the effects of the pesticides when they are swallowed, inhaled, spilled on the skin, or splashed in the eyes. The most hazardous materials are assigned to Toxicity Category I and the least to Toxicity Category IV.

  The signal words "danger-poison," and the skull and cross bones are required on the labels of all highly toxic compounds (corresponds to Toxicity Category I). These materials all fall within the acute dermal LD_{50} (see Chapter 4) range of 0-200 mg/kg. (Note: a few Toxicity Category I compounds may have only the signal word "DANGER."

  The word "WARNING" is required on the labels of all moderately toxic compounds (corresponds to Toxicity Category II). These materials all fall within the acute dermal range of 200-2000 mg/kg.

  The word "CAUTION" is required on the labels of all slightly toxic compounds (corresponds to Toxicity Category III and Toxicity Category IV). These materials have an acute dermal LD_{50} greater than 2000 mg/kg.

  All labels must bear the statement, "Keep out of reach of children."

- Precautionary statement. The label will contain a precautionary statement which will tell you the ways in which

Categories of Acute Toxicity

Categories	Signal Word Required on the Label	Oral	LD_{50} Dermal mg/kg	LC_{50} Inhalation mg/l	Probable oral Lethal Dose for 150 lb man
I Highly Toxic	DANGER—skull and crossbones POISON	0—50	0—200	0—2,000	A few drops to a teaspoonful.
II Moderately Toxic	WARNING	over 50 to 500	over 200 to 2,000	over 2,000 to 20,000	Over one teaspoonful to one ounce.
III Slightly Toxic	CAUTION	over 500	over 2,000 to 20,000	----------	Over one oz. to one pint or one pound.
IV Relatively Non-toxic	CAUTION	over 5,000	over 20,000	----------	Over one pint or one pound

the product may be poisonous. It may, for example, indicate that the product poses a special hazard if inhaled or if splashed in the eye. In either of these cases, the precautionary statement would also indicate what special precautions you should take to protect yourself. For example, the precautionary statement may direct you to use rubber gloves, or an approved respirator, or goggles, when working with the pesticide. The label may indicate that the product may cause undesirable effects in the environment; in this case, the precautionary statement may tell you what to avoid doing. The label may also inform you of unique fire, explosion, or chemical hazards of the product.

- Statement of practical treatment. The label will tell you what first aid measures to take in the event you or someone else is accidently exposed to the pesticide. The label will tell you when to seek medical attention in the event of exposure.

- Directions for use. You will need information about how to mix and apply a particular formulation, what pest it is registered for, where and when to apply the pesticide, how much to apply, and how often to apply the material. The directions for use contain all of this information.

- Misuse statement. This section reminds you that the product may not be used in a manner which is in conflict with the labeling.

- Re-entry information. Some pesticides present a significant hazard to workers and others who enter treated areas before the chemical has had time to degrade to acceptable levels. To protect people from these dangers, the label may warn you to wait a specified period of time after application before allowing re-entry into a treated area without protective clothing. This waiting period may be for several days or even weeks. In California there are special regulations regarding re-entry when certain pesticides are used. ***Remember:*** even if the pesticide label or the California Pesticide Worker Safety regulation does not contain specific restrictions concerning re-entry, you should never allow anyone to enter a treated area until the deposit has dried or until the dust has settled.

- Storage and disposal directions. This section will tell you how to store and dispose of the product and empty containers.

- Residues. If the pesticide is intended for use on food, feed, or livestock, the label may specify an interval between final application and harvest or slaughter. This interval is to allow harmful pesticide residues to be reduced below tolerance levels before the product is consumed. Illegal residues on a food crop may result in loss of the crop, so remember to ***follow label directions carefully.***

- Restrictive statement. The label may contain a statement such as "Do not feed straw or crop residues to livestock," etc. ***This restrictive statement must be complied with.***

SCIENTIFIC BASIS OF LABEL INFORMATION

The information on any registered pesticide label is the product of extensive research performed by many highly trained scientists working with chemical companies that specialize in developing and testing new compounds. As the new chemicals are developed, they are screened for pesticidal properties; only a few of the thousands tested will appear to be potential pesticides. These are tested again and again to measure many of their important properties. Of the thousands of chemicals originally tested, only a very few will become registered pesticides. Each chemical is tested for its ability to control pest species, its toxicity, its residual qualities, its breakdown properties, and its effects on the environment.

The new chemicals are tested against a number of standard laboratory species of insects, weeds, fungi, or other pests. If the chemical kills or in some other way affects

the test species, scientists may decide to make further tests. In this case they will want to know the new compound's toxic properties, which must be well known before the pesticides can be registered. To be registered, the pesticide must be effective on the target species without being so toxic that it presents an unacceptable hazard to people who apply it or are exposed to it in some other way. Also, it must not be excessively harmful to non-target organisms which may be exposed. The toxicity of each new pesticide chemical is measured using standard laboratory tests and test animals, usually rats and rabbits.

Another concern of the company developing the chemical is the persistence of the pesticide. *Persistence* means the length of time that the chemical remains on treated crops or in the environment, or in animals. Some pesticides remain on treated crops or in the environment for a long time, and in many cases this is desirable. In other cases, the long-term persistence is undesirable. In any case, the company must measure the degradation (breakdown) properties of the chemical. This includes determining the length of time it takes for the chemical to degrade and also determining what changes the chemical undergoes as it breaks down under the action of sunlight, water, bacteria, and so on. It is important to know the by-products of chemical breakdown, because in some cases the by-products are more toxic than the original chemical. In addition, whenever a pesticide is intended for use on a food or forage crop, residue tests must measure the amount of residue remaining after treatment and the length of elapsed time needed until the residue remaining on the crop has degraded to an acceptable level.

Pesticides are also tested for their movement in soils, ground water, and other parts of the environment.

Finally, the pesticide is tested for its effects on certain species of wildlife. In particular, fish and birds (frequently trout, goldfish, bluegill, quail, and ducks) are studied to determine whether the chemical will have an adverse effect when placed in the general environment.

Once all this information is gathered by the pesticide developer, it is submitted to various state and federal agencies, such as the Environmental Protection Agency and the California State Department of Food and Agriculture, for review. The governmental review is designed to insure that all label claims are based upon facts supported by valid scientific data, and that the label does not contain false or misleading statements.

The pesticide is registered after the governmental agencies have reviewed the data and found it to be accurate, complete, and within prescribed limits. Only after this registration can the chemical be made available on the open market for controlling the pests or for treating the crops or animals on which it was tested.

Chapter 4

PESTICIDE TOXICITY AND POISONING SYMPTOMS

Preventing human accidental exposure to pesticides is possible through informed use. Therefore, knowledge of the proper precautions to take in using pesticides is a key to safe pesticide handling. This manual provides the basic information you need to enable you to manage your pest problems and avoid injury to yourself, other persons, and the environment. This section will give you basic information on pesticide safety, including: pesticide toxicity, the common exposure routes, and how certain pesticides affect humans.

PESTICIDE TOXICITY AND HAZARDS

All pesticides are toxic (poisonous) in some way to plants, animals, and people. Pesticides vary in degree of toxicity, ranging from only slightly toxic to extremely toxic. There is a distinction to be made between the terms "toxicity" and "hazard." *Toxicity* is the capacity of any substance to produce injury or death, while *hazard* is a function of two factors—toxicity and exposure to a toxic substance. For example, you could handle a sealed container of a very toxic pesticide without becoming ill; but if the container leaks while you are handling it, you might be exposed. Thus, the combination of toxic chemical and leaking container creates a hazard. The hazard of a chemical, then, is a measure of the risk to the user.

Safe handling and use of pesticides requires knowledge of (1) how toxic the substance is, and (2) how to handle the material and equipment so that you and other people are not exposed to it. Since each pesticide on the market has a toxicity rating and is assigned to a toxicity category, you will know the potential danger of the pesticide you are using.

LD_{50} And LC_{50}

In order to understand just how toxic some chemicals really are, it helps to know the way in which toxicity is measured and rated. One of the first questions scientists ask when developing a new chemical intended for use as pesticide is, "What is its toxicity?" To answer this question, the chemical is applied to test animals. Usually rats or rabbits are used, and the chemical is applied to the skin (dermal exposure), fed to (oral exposure), or inhaled by (inhalation exposure) the animal. By testing a number of individual animals, the scientist can quickly find a dosage (or amount) of the chemical which will make some of the animals sick and cause a few to die. Then, with additional testing, it is possible to determine the amount of chemical which will kill one-half (50%) of the animals tested. The amount of chemical required to kill 50% of the test population is referred to as the "lethal dose to 50%," or LD_{50}. This is used as a standard measure of the toxicity of the chemical which will be used in a pesticide formulation.

LD_{50}s are generally expressed in terms of a ratio of the weight of the chemical to the weight of the test animal. For convenience toxicologists use the metric values of milligrams of toxicant per kilogram of body weight of the animals tested. When the material is tested by applying it to the skin of the animals, the result is referred to as the Dermal LD_{50}; when the chemical is tested by feeding it to the animals, the result is referred to as the Oral LD_{50}.

Pesticides and other chemicals are often toxic even when they are inhaled, and some pesticides are naturally a dust or gas. Therefore, it is necessary to have a procedure to measure the toxicity of chemicals in the air. In this case, the material is mixed with air and the test animals breathe the chemical. It can then be determined what concentration of chemical mixed in air kills 50% of the test population; this amount is referred to as the "lethal concentration to 50%," or LC_{50}.

LC_{50}s are generally expressed in terms of a

ratio expressing the parts of chemical to parts of air. Most frequently the ratio is measured in terms of "parts per million" (ppm) or "parts per billion" (ppb): that is, how many parts of dust or gas per million (or billion) parts of air constitutes a concentration lethal to 50% of the population tested.

Acute Exposure

When a single dose of a pesticide is administered, or when a single exposure to a pesticide occurs, it is called an "acute" exposure. Thus, *acute dermal* refers to a single dose applied to the skin; *acute oral* refers to a single dose taken by mouth; and *acute inhalation* refers to a single dose that is inhaled. Pesticides are assigned to toxicity categories on the basis of their acute LD_{50} or LC_{50}.

Chronic Exposure

When there is repeated or continuous exposure to (or dosages of) a pesticide, it is called "chronic" exposure. Thus, toxicity can be described in terms of *chronic dermal*, *chronic oral*, or *chronic inhalation* toxicity.

HUMAN PESTICIDE EXPOSURE

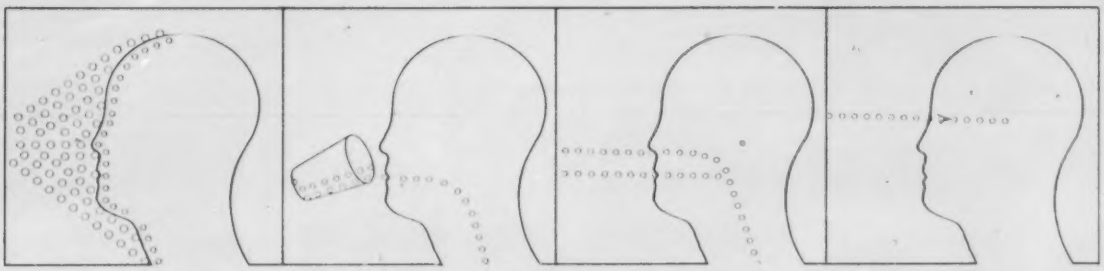
There are four common ways in which pesticides enter the human body: through the skin, the mouth, the lungs, and the eyes.

Dermal Exposure

Absorption through the skin is the most common route of intoxication (poisoning) of agricultural and other workers resulting from exposure to pesticides and other chemicals. This absorption may occur as a result of a splash, spill, or drift when mixing, loading or disposing of the pesticide. It may also result from exposure to large amounts of residue. The degree of dermal absorption hazard depends on the dermal toxicity of the pesticide, the extent of the exposure, the way the pesticide is formulated, and the site of contamination. In general, wettable powders, dusts, and granular pesticides are not as readily absorbed through the skin and other body tissues as are the liquid formulations such as the emulsifiable concentrates, which contain a high percentage of the toxicant in a relatively small amount of solvent. Certain areas of the body, such as the scrotum, absorb pesticides very thoroughly and rapidly. ***Don't take chances: if you become contaminated, wash immediately!***

Oral Exposure

If a pesticide is taken into the mouth in sufficient amounts, it may cause serious illness, severe injury, or even death. Pesticides may be consumed by accident through carelessness or they may be consumed by those intent on causing self-inflicted injury. The most frequent cases of accidental oral exposure are those in which pesticides have been taken from their original labeled container and illegally put into an unlabeled bottle or food container. There are many cases where people, especially children, have been poisoned drinking pesticides from a soft drink bottle. In other cases adults have mistakenly drunk from bottles containing pesticides or been poisoned by drinking water stored in contaminated bottles or other containers. The number of these accidents may be greatly reduced if such dangerous and



illegal practices are eliminated. Follow these rules:

- Always store a pesticide in its original labeled container.
- *Never* use your mouth to clear a spray line or nozzle.
- *Never* eat or smoke until you have left the spray area *and* washed thoroughly.
- Avoid contact with contaminated application equipment, clothing, accumulations of pesticides, and treated crops until the specified re-entry interval is past.

Respiratory Exposure

Pesticides are sometimes inhaled in sufficient amounts to cause serious damage to nose, throat, and lung tissues. The potential hazard of respiratory exposure is great, due to what is considered to be almost complete absorption of pesticides through this route. Vapors and extremely fine particles represent the most serious potential for respiratory exposure.

The potential of pesticide exposure is usually relatively low when dilute sprays are being applied with conventional application equipment. This is due primarily to the larger droplet sizes produced. When low volume equipment is being used to apply concentrated material, the potential of respiratory exposure is increased because of the smaller droplets (or particles) being produced. Application in confined spaces also contributes to increased potential of respiratory exposure. Protection from respiratory exposure is provided by a number of devices such as respirators and gas masks.

Eye Exposure

The tissues of the eye are particularly absorbent, and therefore getting any pesticide in the eye presents an immediate threat of loss of sight, illness, or even death. Eye protection is needed when measuring or mixing concentrated and highly toxic pesticides; protection is also needed when there is a risk of exposure to dilute spray or dust drifts. Protective shields or goggles should be used whenever there is a chance of pesticides coming into contact with the eyes. These pieces of protective equipment should be kept available and clean at all times.

It should now be obvious that pesticides can enter your body in solid, liquid, or gaseous form. It is particularly important to remember that highly concentrated and highly toxic chemicals, especially liquids and gases, present the greatest danger. If they are not removed immediately, the liquid concentrates can readily penetrate the unbroken skin and make you sick. The longer a pesticide remains on your skin or in your eyes, or the longer you inhale it, the greater the damage that is likely to result.

FIELD RE-ENTRY SAFETY INTERVALS

Some highly toxic compounds can leave relatively short-lived residues on plants. Experience has shown that some of these residues constitute a risk to field workers and others who are in prolonged contact with sprayed foliage. Special field *re-entry intervals* have been established to help prevent worker illnesses related to such pesticide residue exposure. Pesticide applicators using materials requiring a re-entry interval should check with the County Agricultural Commissioner for up-to-date information on re-entry regulations.

HOW PESTICIDES AFFECT HUMANS

The ways in which pesticides affect humans and other mammals are commonly referred to as *modes of action.* The modes of action of a number of pesticides in use today are either not known or, in some instances, are only partially understood. Even though it may not be known exactly how a pesticide poisons the body, some of the *signs* and *symptoms* resulting from such poisoning are quite well known. These warning responses of the body to poisoning can be recognized by anyone working with pesticides.

You should learn and be alert to the signs and symptoms of the early stages of poisoning: if any sign of poisoning develops, you should immediately and completely remove the source of exposure. By doing so, you may prevent additional exposure and minimize injury. ***Early recognition of these warnings, and immediate and complete removal of the source of exposure may save a person's life.***

Remember, however, that everyone is subject to various sicknesses or diseases. Therefore it cannot be assumed that, because an individual is in the vicinity of pesticides or a pesticide application, the development of some signs or symptoms of poisoning are necessarily the result of pesticide exposure. Nevertheless, if any signs or symptoms appear after contact with pesticides, you should call your physician and advise him of the nature of the problem and of the pesticide involved.

SYMPTOMS OF PESTICIDE POISONING

Know the poisoning symptoms. Here are some of the more important hazardous pesticide groups and some of the ways they affect humans.

Organophosphorous Pesticides

The organo-phosphate poisons attach themselves to a chemical in the blood that is normally present and necessary for proper nerve functioning. This chemical is an enzyme known as "cholinesterase." The organophosphate pesticides "tie up" the enzyme and make it unavailable to the nerves. When cholinesterase is unable to perform its normal function, the nerves in the body continue to send messages to the muscles. These continuous messages cause the muscles to move constantly. Continuous muscle twitchings and weaknesses are referred to as "tremors" or "fibrillations." If the muscle action becomes intense, the victim may have fits or convulsions. In cases of severe poisoning, quick and proper medical treatment can still save persons in the advanced states of organophosphate (or carbamate) poisoning, even though they may be near death. The signs and symptoms go through stages from mild to severe poisoning.

Carbamate Pesticides

The mode of action of these compounds is very similar to that of the organophosphate

SYMPTOMS OF ORGANOPHOSPHATE POISONING

Mild Poisoning	Moderate Poisoning	Severe Poisoning
Fatigue	Unable to walk	Unconsciousness
Headache	Weakness	Severe constriction of pupil of eye
Dizziness	Chest discomfort	Muscle twitching
Blurred vision	Constriction of pupil of eye	Secretions from mouth and nose
Too much sweating and salivation	Earlier symptoms are more severe	Breathing difficulty
Nausea and vomiting		Coma and death
Stomach cramps or diarrhea		

compounds in that they inhibit the enzyme cholinesterase. But because the carbamates are broken down in the body rather rapidly, their effect on cholinesterase is quite brief. Carbamates are therefore referred to as "rapidly reversing inhibitors" of cholinesterase. The reversal is so rapid that, unless special precautions are taken, measurements of blood cholinesterase of human beings exposed to carbamates are likely to be inaccurate and always in the direction of appearing to be normal.

The symptoms of carbamate poisoning are essentially the same as those caused by the organophosphorous pesticides.

Chlorinated Hydrocarbon Pesticides

Compounds in this group, also known as *organochlorine pesticides*, were used extensively until recently, when some were restricted or banned from use. The chlorinated hydrocarbons act on the central nervous system, but the mode of action is not known. It is known that these compounds and their degradation products can be stored in the fatty tissues as a result of either large single doses or repeated small doses. Single large doses can cause liver and kidney damage in animals, but these effects have not been demonstrated in humans. Symptoms of chlorinated hydrocarbon pesticide poisoning include nervousness, nausea, and diarrhea. Convulsions or severe nervousness may result from exposure to a large dose.

Nitrophenol Pesticides

Compounds in this group are used as fungicides, insecticides, and herbicides in different formulations, and can be absorbed in toxic amounts through oral, respiratory, or dermal exposure. Nitrophenol poisoning speeds up certain body processes and may cause fever, sweating, rapid breathing, rapid heartbeat, or unconsciousness. In cases of a single, large exposure to some of the nitrophenols, the signs and symptoms of poisoning may occur rapidly. If death occurs it probably will be within 24 to 48 hours. However, if the patient receives adequate medical attention and the exposure to the chemical has not been severe, the patient probably will recover completely. In cases of chronic nitrophenol poisoning, symptoms such as nervousness, sweating, unusual thirst, and loss of weight have been observed.

Bypyridyliums

This group of herbicides may be fatal if swallowed, and harmful if inhaled or absorbed through the skin. Lung fibrosis may develop if these materials are taken by mouth or inhaled. Prolonged skin contact will cause severe skin irritation. Symptoms of injury may be delayed. There are no adequate treatments, and the effects of oral poisoning by paraquat are generally irreversible.

Botanical Pesticides

These pesticides vary greatly in their chemical structure and also in their toxicity to humans. The toxicity of these pesticides ranges from pyrethrum, which is one of the least toxic of all insecticides to mammals, to strychnine, which is one of the most toxic.

Pyrethrums. These pesticides are becoming more and more important since the active ingredient, pyrethrin, has been identified, thereby enabling the manufacture of synthetic pyrethrin-like compounds called "pyrethroids." They exhibit a wide range of toxicity, from very low to very high. They are used against many insect pest species. Some mild symptoms resulting from human exposure to pyrethrum are skin allergies, sneezing, and runny nose.

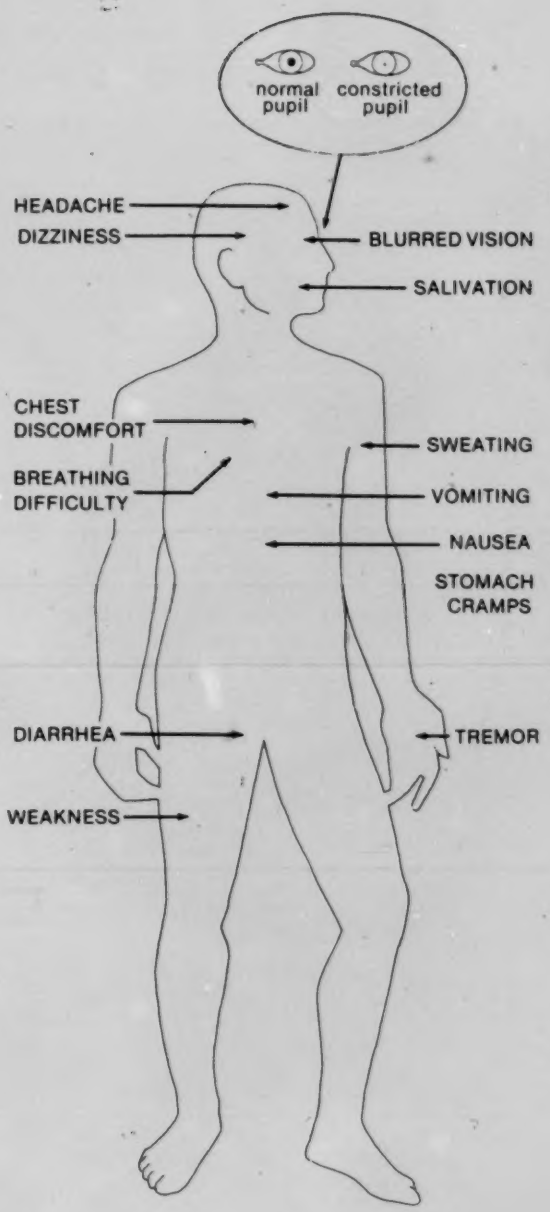
Strychnine. Strychnine is a highly toxic poison; doses as small as 16 mg have been known to be lethal to an adult. Within 10 to 30 minutes of swallowing strychnine the victim exhibits symptoms. There may be a series of violent convulsions or fits at intervals of 10 to 15 minutes. Between convulsions the victim usually relaxes, and may fall asleep. Any stimulus, such as a noise, may trigger another convulsion. If the victim survives the first 5 or 6 hours, there is a good chance of recovery.

Fumigation Materials

Most fumigation materials are highly toxic and extremely dangerous when inhaled. Because of the nature of their use, they are extremely hazardous in enclosed areas. Methyl bromide and chloropicrin are widely used and highly toxic fumigants.

Methyl bromide. This compound affects the protein molecules in certain body cells. The symptoms of poisoning produced by methyl bromide are severe chemical burns of the skin and other exposed tissue, delayed chemical pneumonia (which produces water in the lungs), and severe kidney damage. Extreme nervousness may also result. Any of these effects can be fatal. If smaller amounts of methyl bromide are inhaled, an effect similar to alcoholic intoxication may be produced. Repeated mild exposures accumulate and produce skin rashes. Sometimes mental confusion, double vision, tremors, and lack of coordination follow, and the person's speech may be very slurred. Victims have been jailed or sent to mental hospitals by mistake.

Chloropicrin. This is also a highly hazardous chemical, but, unlike methyl bromide, it gives off a gas with an odor and is very irritating to the eyes. The material is also used as tear gas, and is sometimes mixed with methyl bromide as a warning agent.



WARNING

Know the pesticide poisoning symptoms. ***Do not let yourself or anyone else get dangerously sick before calling your doctor.*** It is better to be too cautious than too late. Take the label of the pesticide to the doctor or hospital emergency room along with the victim. Do not let the sick person go alone to the doctor or hospital—the victim might not be able to drive or think well enough to get there safely, if at all.

Chapter 5

FIRST AID FOR PESTICIDE POISONING

It is essential that pesticide poisoning incidents be recognized immediately because prompt treatment may mean the difference between life and death. Remember that first aid is not a substitute for professional medical treatment: ***first aid is only to relieve the patient until medical help is available.*** Know what first aid procedures to follow in poisoning emergencies.

IF YOU ARE THE VICTIM

If you are exposed to a pesticide while you are working alone, remain calm. The serious effects of pesticides are generally not instantaneous, so you will have some time to protect yourself. (***Note:*** You should get any spilled pesticide off your body ***as fast as you can.***) If you act quickly and intelligently, you will minimize the effects of the pesticide, and you may save your own life.

If the pesticide is on your clothes:

- Remove them at once and rinse your skin immediately with any uncontaminated water available.
- Wash with detergent and water after you have rinsed.
- ***Call or send for help while you are rinsing and washing!*** (For example, if there is a phone near the hose you are using to rinse yourself, call on the phone for help while you are rinsing; or, if there are people within hearing range, shout for help while you rinse yourself.)

If you have been exposed to a highly toxic pesticide, and you are beginning to feel any illness:

- Have someone ***take you and the label or labeled container to the doctor.***
- ***Do not delay!***

If you have accidentally swallowed a pesticide and then realize what you have done:

- Read the label and determine whether or not to induce vomiting.
- If the label recommends vomiting, induce it at once by putting your finger down your own throat: ***this may save your life.***
- ***Get to a doctor.***

If you splash or spill a pesticide in your eyes:

- Wash your eyes with water ***at once.***
- Use a clear stream of running water, keep your eyes open, and ***wash for at least 15 minutes.***
- Do ***not*** use any medicated eyewash.
- ***Call or send for help while you are washing your eyes.***
- After washing your eyes for 15 minutes, ***get to a doctor*** and ***take the label or labeled container with you.***

In any case, if you swallow a pesticide or get some in your eyes, see a doctor ***before symptoms develop.*** Any delay can cause temporary or permanent blindness or other injury; it could even be fatal.

IF YOU ARE ALONE WITH THE VICTIM

- See that the victim is breathing; if not, give artificial respiration.
- Decontaminate the victim immediately —that is, wash the person off thoroughly. ***Do not contaminate yourself in the process.***
- Call your doctor.

IF ANOTHER PERSON IS WITH YOU AND THE VICTIM

- Speed is essential: one person should begin first aid treatment while the other calls a doctor.
- The physician will give you instructions. He will very likely tell you to get the victim to the emergency room of a hospital, where the equipment needed for proper treatment is available. Only if this is impossible should the doctor be called to the site of the accident.

GENERAL INSTRUCTIONS

- Give mouth-to-mouth artificial respiration if breathing has stopped or is labored.
- Stop exposure to the poison and if poison is on the skin, thoroughly cleanse the person, including hair and fingernails. If swallowed, and the pesticide label recommends vomiting, induce vomiting. If poison is in the eyes, wash the eyes with water for 15 minutes.
- Save the pesticide container and material in it (if any remains), and get a readable label or the name of the chemical(s) and bring it to the doctor. ***If the poison is not known, save a sample of the vomitus*** for analysis.

SPECIFIC INSTRUCTIONS

Poison on Skin

- Remove clothing.
- Drench skin with water (shower, hose, faucet).
- Wash skin, hair, and fingernails thoroughly with soap and water; speed in washing is most important in reducing the extent of injury.
- Dry the victim and wrap in a blanket.

Poison in Eyes

- Hold eyelids open; wash eyes ***immediately*** with gentle stream of clean running water. Use large amounts of water. ***Delay of a few seconds greatly increases extent of injury.***
- Continue washing for 15 minutes or more.
- Do ***not*** use chemicals or drugs in wash water: they may increase the extent of injury.

Inhaled Poisons (dusts, vapors, gases)

- If victim is in enclosed space, do ***not*** attempt to rescue without proper respiratory equipment.
- Carry patient (do not allow walking) to fresh air immediately.
- Open all doors and windows, if any.
- Loosen all tight clothing.
- Apply artificial respiration if breathing has stopped or is irregular.
- Call a doctor.
- Prevent chilling (wrap patient in blankets but don't overheat).
- Keep patient as quiet as possible.
- If patient is convulsing, watch breathing and protect from falling and striking head on the floor or wall. Keep patient's chin up so air passage will remain free for breathing.
- Do ***not*** give alcohol in any form.

Swallowed Poisons

- Call a doctor immediately.
- Do not induce vomiting if:

  Patient is unconscious.

  Patient is in convulsions.

  Patient has swallowed petroleum products—kerosene, gasoline, lighter fluid, etc.

  Patient has swallowed a corrosive poison (strong acid or alkaline products); symptoms include severe pain, and burning sensation in mouth and throat. A corrosive substance is any material which in contact with living tissue will cause destruction of tissue by chemical action; examples include lye, acids, etc.

- If the patient can swallow after ingesting a corrosive poison, give the following substances by mouth:

  For acids—milk, water, or milk of magnesia; one tablespoon to one cup of water.

  For alkali—milk or water; for patients 1—5 years old, one to two cups; for patients 5 years and older, up to one quart.

Chemical Burns of Skin

- Remove contaminated clothing.
- Wash with large quantities of running water.
- Immediately cover with loosely applied clean cloth (any kind will do).

- Avoid use of ointments, greases, powders, and other drugs.
- Treat shock by keeping patient flat, warm, and reassured until the arrival of a doctor.

How To Induce Vomiting When A Non-Corrosive Substance Has Been Swallowed

- Induce vomiting by placing the blunt end of a spoon (not the handle), or your finger, at the back of the patient's throat; or use an emetic of two tablespoons of salt in a glass of warm water.
- When retching and vomiting begin, place patient face down with head lowered, thus preventing vomitus from entering the lungs and causing further damage. Do *not* let patient lie on back.
- If there is some difficulty in getting the patient to vomit, it is better to start moving toward the hospital; perhaps vomiting can be induced en route to the hospital. It is important to begin heading for the hospital, especially if it is a long distance away, because the hospital is where drugs can be administered to induce vomiting and stomach pumps are available.
- Clean vomitus from the patient. Collect some vomitus in case the doctor needs it for chemical tests.

SUGGESTED CONTENTS OF FIRST AID KIT

If you plan to work with any pesticide, and especially if you intend to use any of the highly toxic chemicals, you should have available a specially designed first aid kit. This first aid kit may save your life; ***keep it handy.*** Your first aid kit should include the following:

- Plastic bottle of detergent to wash pesticides off the skin.
- Plastic container of salt to induce vomiting.
- Plastic container of baking soda or bottle of milk of magnesis to neutralize acidic chemicals that have been swallowed.
- Plastic bottle of lemon juice or vinegar to neutralize basic or alkaline chemicals which have been swallowed.
- Bag of activated charcoal to mix with water and swallow to act as pesticide absorber.
- Shaped plastic airway to use for mouth-to-mouth resuscitation.
- Plastic bottle of clean water to dilute the salt, baking soda, lemon juice, or vinegar; also, to mix with charcoal.
- Band aids, bandages, and tape.
- Blanket to cover the victim.
- Cups for drinking.
- Dime to make emergency phone calls.

POST EMERGENCY INFORMATION

At the work site you should post the name, address, and current telephone number of the physician, clinic, or hospital emergency room that will provide care in the event a person should be poisoned. ***This is mandatory if you have employees working with pesticides.***

Chapter 6

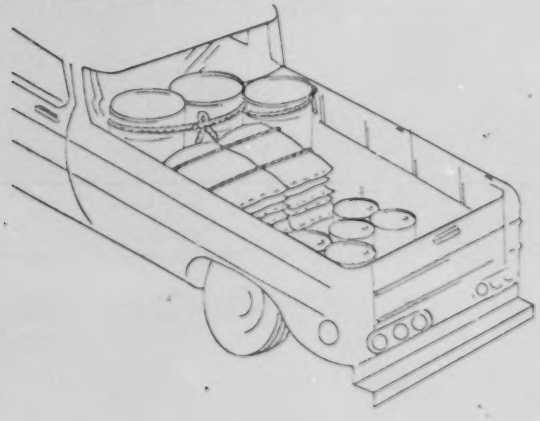
HOW TO HANDLE PESTICIDES

Pesticides can poison people, pets, and livestock; they can damage beneficial insects, birds, fish, and wildlife; and they can harm desirable plants at any time. It is necessary to maintain careful and continuous control over the use and handling of these chemicals during transport, storage, mixing and loading, application, and disposal. Care must be exercised in cleaning equipment, clothing, and persons working with pesticides. Additionally, special precautions are necessary should pesticides be spilled or catch fire.

TRANSPORTING PESTICIDES

Pesticides can present a particularly severe hazard if they are involved in accidents during transportation. When pesticides are spilled on the roadway, they may catch fire, be scattered by passing cars and trucks, be blown by wind onto nearby crops or people, or be washed into ditches or streams by rain. If they catch fire, the fumes and smoke may injure firefighters, police, and people far removed from the scene of the accident. Less spectacularly, pesticides may simply contaminate the vehicle, cargo, or people transporting the chemicals. When you transport pesticides, you are legally responsible for their safety. Taking the following precautions will help prevent accidents.

- Pesticides are most safely transported in the back of a truck.



- *Never* transport pesticides in the passenger compartment of any vehicle.
- *Never* allow children to ride in the back of a pick-up truck with pesticides; a spill could cause severe injury or death.
- *Never* transport pesticides in the same compartment with food, feed, or clothing.
- Secure all containers to prevent any spillage.
- Protect containers made of paper, cardboard, or similar materials from moisture.
- Protect glass containers from breakage.

STORING PESTICIDES

It is necessary and legally required that pesticides be stored in a safe, secure, and well-identified place. Here are a few rules to follow:

- Pesticides must always be stored in the original, labeled container with the label clearly visible.
- ***Never store pesticides in old bottles or food containers*** where they could be mistaken for food or drink for humans or animals.

- *Never* store pesticides near food, feed, or seed.
- Always store them in tightly sealed containers; check periodically for leakage, corrosion breaks, tears, etc.
- Always store them where they are protected from freezing or excessive heat.
- Always be certain that the storage area is well-ventilated to prevent the accumulation of toxic fumes.
- Some pesticides should not be stored together. This is especially true of the hormonal herbicides which should not be stored with insecticides or fungicides.

When small amounts of pesticides are to be stored—at home, for example—keep them in a ***locked***, dry cabinet or storage shed where humans (especially children), pets, and livestock cannot come into contact with them. Children are curious; they don't know the hazards of these chemicals, and they don't or can't read labels.

When larger amounts of pesticides are being stored, let's say on a farm, they should be stored in a separate building with fire-resistant construction, adequate ventilation, and proper security to prevent accidental exposure to people and the environment.

DANGER
PELIGRO

POISON STORAGE AREA
ALMACEN DE VENENOS

ALL UNAUTHORIZED PERSONS KEEP OUT
SE PROHIBE LA ENTRADA
A TODO PERSONAL SIN AUTORIZACION

KEEP DOOR LOCKED WHEN NOT IN USE
MANTENGAN LAS PUERTAS CERRADAS
CUANDO NO ESTE EN USO

MIXING AND LOADING PESTICIDES

A great many pesticide accidents occur when the chemicals are being mixed for use. A recent study of pesticide accidents in California gives some idea of the kind of situations which most frequently lead to occupational illnesses caused by pesticide chemicals. This study has revealed that the most dangerous pesticide-use job is pouring

and mixing the concentrated chemicals; that the organophosphate insecticides are the most hazardous pesticides; and that, when these insecticides are in xylene, they present the most serious safety hazards. The same study shows that the low-volume and ultra-low-volume dilutions are the most hazardous to apply because they are the most concentrated.

A few common sense rules can make mixing and loading safer, thereby helping you to avoid the leading cause of pesticide-related illnesses.

- Before handling a pesticide, ***put on the correct protective clothing*** and other necessary protective equipment. Read the label for instructions on what special equipment is necessary. If you

have questions concerning protective equipment, contact your county agricultural commissioner or other expert before you open the container.
- Mix the pesticides outdoors, in a place where there is good light and ventilation. If you must mix or load pesticides indoors or at night, make sure you have good ventilation and lighting.
- Stand upwind of the pesticide to avoid contaminating yourself.
- Use a sharp knife to open paper bags; do not tear them.
- Measure accurately; use only the amount specified on the label.
- When removing the concentrated material from the container, keep the container below eye level to avoid splashing or spilling any pesticide into your face and eyes.
- If you splash or spill a pesticide while mixing or loading, ***stop immediately!*** Remove contaminated clothing, and wash thoroughly with detergent and water—speed is essential when you or your clothing are contaminated. Clean up the spill.

APPLYING PESTICIDES

Careful attention to a few simple guidelines during pesticide application will greatly increase your chances of effectively controlling the pest. At the same time, attention to these details will make the job much safer for you, other people, pets, livestock, and the surrounding environment.

1. Before you begin the application, ***read the label.*** Don't trust your memory for details concerning the use of any pesticide. You may remember correctly what the label said, but manufacturers and formulators often change label directions without changing the brand name of the pesticide. Therefore, make certain that you are informed.
2. Check the application equipment. Look for leaking hoses or connections, plugged or worn nozzles, and examine the seals on the filter openings to make sure they will prevent spillage of the chemicals.
3. Mix the pesticide at the recommended rate, and apply at the specified dosage. Do not exceed the dosage recommended on the label or the written recommendation of a qualified person.
4. Calibrate your equipment before use. Make certain that your equipment is adjusted according to the manufacturer's specifications. This will assure that the proper dosage is being applied to the target site.
5. Before pesticide application is begun, clear all livestock, pets, and people from the area to be treated.

6. Apply pesticides only at the correct time and under acceptable weather conditions. Never apply a pesticide if winds will cause substantial drift of the chemical out of the target area. If winds come up during the operation, ***stop immediately***, and do not begin the application again until conditions improve. Avoid applying pesticides when temperatures are high. Be especially careful when temperatures exceed 85°F.
7. When handling highly toxic pesticides, do not work alone.
8. Use extreme care to prevent the pesticide from contaminating streams, ponds, lakes, or other bodies of water.
9. Avoid situations where the pesticide may be blown or washed onto people, pets, or livestock.
10 Do not contaminate food or feed through careless application methods.

EQUIPMENT CLEAN-UP

After completing the application of any pesticide, it is necessary to immediately clean the mixing, loading, and application equipment. The cleaning operation can be somewhat hazardous if proper precautions are not followed. People who clean the equipment must (1) know the correct procedures and (2) wear the appropriate clothing, including rubber boots, goggles, apron, and gloves. The actual cleaning should be done in a specific area, preferably on a wash rack or cement apron that has a well-designed sump to catch all contaminated wash water and pesticides for later disposal.

DISPOSAL METHODS FOR PESTICIDE WASTES— GENERAL CONSIDERATIONS

Waste materials should be considered hazardous to the public and to people handling them. These materials are also potential pollutants of water, air, and land.

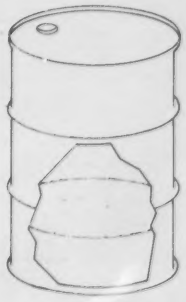
Deciding how to dispose of pesticide wastes should be done on a case-by-case basis. Consult basic chemical manufacturers, if possible, for special instructions regarding specific products. Some pesticide manufacturers may accept small amounts of waste for disposal at the factory.

Disposal of Pesticide Containers

Disposing of pesticide containers is a significant problem, particularly if you have a large number of unwanted containers. Research is underway to develop disposable containers and other means of handling the empty container problem. For current regulations concerning the disposal of any pesticide container, contact your County Agricultural Commissioner.

Before disposing of any metal or glass pesticide container, it must be rinsed. The correct rinse procedure follows:

1. Empty the container into the mixing tank and allow the pesticide to drain for an extra 30 seconds. (Do not fill the tank to the desired level yet—first complete the triple rinse method described here, adding the rinse solution to the tank as described in #4 below.)

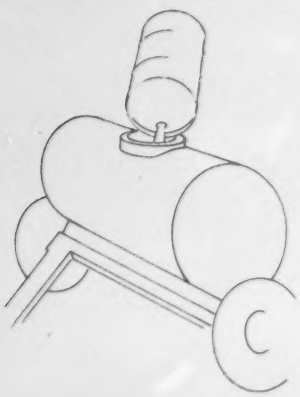


2. Add the correct amount of water for thorough rinsing as follows:

Size of container	*Amount of rinse water*
Less than 5 gallons	1/4 container volume
5 gallons or over	1/5 container volume

3. Replace the container closure; then rotate and shake the container, upending it in the process so that the rinse reaches all interior surfaces.

4. Drain the rinse solution from the container into the mixing tank. Allow the container to drain for an extra 30 seconds after emptying.



5. ***Repeat this rinsing procedure at least two more times for a total of three rinses.***
6. ***Remember***—It is important to empty each rinse into the mixing tank so that the pesticide goes on the target for which it is intended. (This procedure is also a money-saver!)
7. Now that the triple rinse procedure is completed, fill the mixing tank to the desired level.
8. ***Warning: Never pour pesticides down the drain or flush them down the toilet!***
9. ***Note:*** State regulations may require that pesticide application equipment have special continuous or jet rinse capabilities. For additional information on these requirements contact your County Agricultural Commissioner.

Even after rinsing, the washed container still contains some pesticide and should not be considered safe for other uses. ***Do not put any other pesticide into the empty container.*** Most containers will be discarded after one use.

California regulations concerning pesticide container disposal do not apply to containers in which household pesticides have been packaged. However, these containers (except aerosol cans) should be rinsed carefully and destroyed to prevent their reuse.

Disposal Of Unused And Excess Pesticides

Disposing of unused (still in the original container) and excess (already mixed, but not needed) pesticides is a critical problem, particularly if you have a large amount of unwanted chemical. At present there is no simple solution to this problem. Many agencies and universities are hard at work trying to devise safe and efficient solutions to the dilemma posed by pesticide disposal. You should keep in contact with your local County Agricultural Commissioner to be sure that you are using the most up-to-date and legal disposal methods.

The best precaution against pesticide disposal problems is good planning, which begins with buying and mixing the right amount of pesticide to meet your needs. If you should end up with unused or excess pesticide, try to find another person or area with the same pest problem, so that the pesticide gets used up legally and effectively. If you cannot find another area with the same problem, you might decide to locate a disposal site for your unused or excess chemicals. The County Agricultural Commissioner has specific information on local regulations and pesticide dump sites.

PERSONAL CLEAN-UP

After you have completed the pesticide application, disposed of excess material, and cleaned the application equipment, you should thoroughly wash and dry all your protective equipment.

Next, remove your work clothes and place them in an area separate from other laundry items. Do not allow children to play in or

with the contaminated clothing. The pesticides on your work clothes may harm other people who touch them, so warn whoever will be washing the clothes of the possible danger, and tell this person that pesticide-contaminated clothing should be washed separately from other clothing.

Now take a shower. Wash yourself completely with soap and water. Include your hair and fingernails in the wash-up. After showering put on a complete change of underwear and clean outer clothing.

PESTICIDE SPILLS AND FIRES

In spite of the most careful use and handling of pesticides, accidental spills and fires occasionally occur. These range in size from small spills of a household pesticide container to huge fires involving entire manufacturing warehouses filled with the most toxic pesticides. Intelligent preplanning, knowledge of the chemicals involved, and calm consideration of the actual hazards to be dealt with during the emergency will reduce the risk and damage resulting from the accident.

Pesticide spills happen in the home, in the garden, on the farm, and on public highways. When a spill occurs, it should be cleaned up as quickly and safely as possible. After the clean-up is completed, the affected area should be decontaminated immediately and returned to its original condition. A few general rules apply to all pesticide decontamination situations.

- Avoid exposure of people and animals to the pesticide. If you spill any pesticide, immediately see to it that no one is exposed or contaminated by accidentally walking into the spill or breathing the fumes.
- If the spill is on ***private property***, such as in a home or on a farm, begin clean-up procedures immediately, which starts with putting on protective clothing so that you do not contaminate yourself.
- Provide some sort of a barrier to the spread of the pesticide. A barrier may be made of dirt, sawdust, old newspapers, or anything that will soak up the pesticide.
- Remove the contaminated materials to a safe place. If the spill is inside the home or another building, soak up liquid pesticides or sweep up powders and remove them to the outside. Ventilate the area to prevent the buildup of toxic fumes.
- Decontaminate the affected surface: consult the label for specific disposal and decontamination instructions. Many (but not all) pesticides can be detoxified by washing with chlorine bleach and detergent. Add household bleach to the wash solution. Take care to prevent the wash solution from spreading and contaminating a larger area.
- If the spill involves a ***public area***, such as a highway, notify the police, sheriff's office, fire department, the highway patrol, or other local emergency services agency.
- While waiting for emergency personnel to arrive, do what you can to prevent others from being exposed to the pesticide. ***Remember:*** If you know that the spilled pesticide is a highly toxic material, you may save lives simply by insisting that no one drive or walk through the spilled material. When emergency services personnel arrive, tell them about the nature of the chemical. Most police and fire people will know something about chemicals, but they may not appreciate the degree of hazard. Explain to them what you know about the pesticide involved. If it is a Toxicity Category I or II pesticide, their lives may depend on your warning!

Pesticides may be involved in fires in the home or garage, in grocery or other retail stores, in feed and fertilizer stores, in formulators' mixing plants or warehouses, and in freight cars or trucks. Whenever pesticides are involved in fires, they create special hazards. Anyone in the vicinity of the fire may be exposed to toxic fumes, poisonous runoff, and concentrated pesticides from leaking or exploding storage

containers. Here are some general rules that apply to pesticide fires.

- ***Before any fire occurs***, tell the local fire department what you are storing, where you are storing it, and supply them with any information they may request concerning the nature of the chemicals. This may allow them to prepare for possible emergencies and may save lives and property.
- Whenever possible, use foam or carbon dioxide (rather than water) to fight pesticide fires.
- Evacuate and isolate the area downwind of the fire. Fires often attract spectators; keep them away from areas where they might be exposed to smoke and fumes from the blaze. Make sure they are not exposed to runoff from the fire.
- Wear personal protective equipment. If your application safety equipment is not involved in the fire, use it to protect yourself against spills, splashes, and especially toxic fumes.
- ***Avoid poisoning: Stay out of smoke, mist, spray, runoff, and concentrated pesticide.*** Use protective safety equipment!
- Don't take unnecessary risks in fighting the fire: it is better to wait for the fire department than be poisoned.
- If you fight the fire yourself, attack it from a safe distance and from the upwind side. Stay back if there is any possibility of drums, cans, or bottles exploding during the fire.
- Contain the fire. Try to keep both the fire and the pesticide from spreading while you wait for the fire department to arrive. Cool nearby pesticide containers; move vehicles, rail cars, and any threatened mobile equipment if it is safe to do so.
- Use as little water as possible in fighting the fire. Apply the water with a fogging nozzle, not with a straight stream. Straight streams may spread the fire and scatter the pesticide.
- Excess water used in fighting the fire may run off and contaminate the surrounding area. If necessary, construct dikes to prevent the flow of water and pesticides into sewers, irrigation water, or streams.
- Inform the fire department when you report the fire that pesticides are involved. When they arrive, inform them again of the nature of the fire and any special information you may have about the pesticide involved that will aid them in fighting the fire and at the same time protect themselves and others in the vicinity of the fire.

For additional information on clean-up and decontamination following a pesticide fire or spill, contact the pesticide manufacturer. Each pesticide manufacturer maintains a team of experts who are familiar with the specific problems associated with accidental misuse of their products. Often a single phone call to the manufacturer will supply you with enough information to solve a difficult decontamination problem. For information on the manufacturer of the pesticide, look on the label. Telephone numbers may be obtained from the Information Operator, the County Agricultural Commissioner's office, and from local farm advisors.

In cases where large spills of very toxic materials have occurred, the police or fire department responding to the emergency call will seek the aid of specialized agencies which deal only with such chemical emergencies. However, your first contact in a large pesticide spill or fire should be the local emergency services agency.

CHECKLISTS FOR AVOIDING PESTICIDE EXPOSURE

For Avoiding Dermal Exposure

1. Check the label for special instructions or warnings regarding dermal exposure.
2. Use recommended protective clothing and other equipment as listed on the label.

For Avoiding Oral Exposure

1. Check the label for special instructions or warnings regarding oral exposure.
2. *Never* eat, drink, or smoke while working with any pesticide.
3. Wash thoroughly with soap and water before eating, drinking, or smoking.
4. Do not touch lips to contaminated objects (such as nozzles).
5. Do not wipe mouth with contaminated hands or clothing.
6. Do not expose lunch, beverages, drinking vessels, or cigarettes to pesticides.
7. Wear a face shield when handling concentrated pesticides.

For Avoiding Respiratory Exposure

1. Read the label to find out if respiratory protection is required.
2. If respiratory protection is required, use only an approved respiratory device.

For Avoiding Eye Exposure

1. Read the label to find out if eye protection is required.
2. If eye protection is required, use goggles to protect your eyes or a face shield to protect your eyes and face.

Chapter 7

PROTECTIVE CLOTHING AND OTHER SAFETY DEVICES

The hazard of individual contamination from pesticides varies with the type of potential exposure. People who handle pesticides during loading or mixing may become contaminated with the pesticide in its most dangerous form: the concentrated material. Those who apply only the diluted material during ground applications are less likely to be exposed to the concentrated material; however, each year many pesticide applicators and others are made ill from the toxic effects of pesticides. Flaggers usually do not handle pesticides, yet they may be accidentally contaminated during aerial applications: occupational illnesses among these workers are reported with some frequency. Finally, aerial applicators themselves may become contaminated, especially if they load their own aircraft and do not use a closed pesticide transfer system. This is particularly dangerous since becoming ill while flying an airplane can be disastrous.

Illness resulting from pesticide application generally occurs because of skin, eye, or lung contamination. Various devices are available and frequently required by label directions and regulations for use when mixing, loading, or applying pesticides. Use of these protective devices offers some protection against exposure. However, you should understand that protective devices do not eliminate the necessity for other essential precautions.

MINIMUM PROTECTIVE CLOTHING

Whenever you handle pesticides, you should wear a clean hard hat and coveralls, or a long sleeve shirt and full length pants. You should not haul pesticides, place them in storage, or clean or dispose of empty pesticide containers without wearing the proper protective equipment. Also, when you are cleaning any equipment contaminated with pesticides, cleaning up after a spill, or repairing contaminated equipment, you should use the proper safety equipment.

The extent of protective equipment required is determined by the degree of hazard of the pesticide. Some general guidelines for interpreting pesticide label statements which require protective clothing and equipment are available from the California Department of Food and Agriculture.

TYPES OF PROTECTIVE CLOTHING

Skin contamination is the leading cause of pesticide illness. Therefore, protecting the skin should be given first priority. Coveralls, aprons, spray suits, gloves, hats, boots, goggles, and face shields are designed to protect pesticide users from getting the pesticide on the skin or into the eyes.

Coveralls

There are two types of coveralls: disposable and reusable. Disposable coveralls are lightweight and reasonably comfortable in hot weather; they offer good protection if they are not damaged; and, if you follow the directions, many can be laundered and used several times. If they become severely contaminated, they should be discarded at once.

The second type of coverall is made of washable fabric and may be reused many times. These fabric coveralls are adequate for use with all but the most highly toxic and concentrated pesticides.

Aprons

Coveralls protect your ordinary work clothes and are adequate protection after the pesticide has been diluted. However, when pouring or otherwise handling concentrated pesticides, not only is it good sense but you may be required by the label

to wear additional protection in the form of an apron. The apron protects the front of your body from spills or splashes of the concentrate. The apron you use should be made of rubber or a synthetic liquid-proof material. Be certain the apron will resist the solvents used in formulating the pesticide. It should cover your body from your chest to your boots.

Spray Suits

When spraying a Toxicity Category I or II material, the label may require that you wear a waterproof outfit, for example, a rainsuit. This covers your work clothes, is liquid-proof, and made of tear-resistant plastic. Follow the manufacturer's recommendations in cleaning, decontaminating, and caring for your spray suit. Whole body spray suits tend to become hot in warm weather: applications should be completed when temperatures are low enough so that applicators will be able to work under conditions that are both safe and comfortable.

Gloves

The skin on your hands can absorb pesticides and their solvents. Protect your hands by wearing liquid-proof gloves. Natural rubber gloves may be used when handling organophosphorous or carbamate pesticides. Unlined flexible plastic gloves are considered best. Be sure that they are designed for use with solvents and pesticides.

Note: Never use gloves that have a cloth lining, wristband, or are made of leather. These materials soak up pesticides, are very difficult to clean, and may become the source of contamination leading to constant (chronic) exposure.

Before using a pair of gloves, check them for leaks by filling each glove with water and squeezing. Should any water leak out, even from tiny pin holes, discard the gloves. Remember: Lined, leather, or leaky gloves are often worse than no gloves at all!

When using your gloves, wear your sleeves *outside* your gloves. This will prevent spills and splashes from running into your glove and onto your hand.

Hats

Ordinary felt or straw hats with leather sweatbands are dangerous if worn by pesticide applicators. Hats made of these materials may absorb the poisonous chemicals. Anyone wearing a contaminated hat will be exposed to the pesticide. Even small amounts of moderately or slightly toxic pesticides may cause severe skin irritation or other illness if exposure continues for several days.

Pesticide workers should use a liquid-proof hat preferably made of washable plastic. The hat may be a hard hat or it may be made of flexible plastic; in either case it should have a plastic sweatband. Wash the entire hat after use and before storing.

Boots

When loading, mixing, or spraying large amounts of pesticides of any category or when mixing or loading any amount of Toxicity Category I or II pesticides, you should wear liquid-proof, unlined overshoes or boots. These boots are available in a variety of styles and materials. Knee-length boots offer greater protection because they extend above the lower end of the apron. Avoid leather or fabric boots and shoes because these will absorb pesticides and cannot be cleaned effectively.

When wearing boots, wear your pant legs *outside* of your boots. This will prevent spills and splashes from running into the boot and onto your leg. Wash and dry your boots thoroughly, inside and out, after each use.

CARE OF CLOTHING

Wear clean clothing daily. If your clothes get wet with spray, change them immediately. If they are wet with pesticide concentrates or highly toxic pesticides, ***normal washing methods will not get them clean: dispose of them in a safe manner!***

Do not store or wash contaminated clothing with the family laundry. Wash them separately with detergent, household bleach, and hot water. If you have any employees, make sure that they are provided with

clean clothing as required by state and federal regulations.

TYPES OF EYE, MOUTH, AND FACE PROTECTION

Protecting the face, mouth, and most importantly the eyes from pesticide sprays and splashes makes good common sense. Moreover, the use of face and eye protection is required when mixing, loading, or applying many Toxicity Category I and II pesticides.

Goggles

It is especially important that the eyes be protected by goggles when handling dusts, wettable powders, or granules. Goggles are manufactured so that they offer effective eye protection, yet are non-fogging. Many will fit over ordinary eyeglasses.

Note: Many goggles have a headband that is made of a material that readily absorbs chemicals. If you have goggles with this type of headband, wash it after each use, or, better still, replace it with one made of non-absorbent material. Wash goggles with soap and water after each use.

Face Shields

Goggles offer eye protection, but frequently full face protection is advisable or required by the label. It is especially important to protect your eyes and face when pouring or mixing liquid concentrates of highly toxic pesticides. Effective face shields are made of clear plastic; they attach to the hard hat and can be raised or lowered as needed. After each use wash the face shield with soap and water.

TYPES OF PERSONAL RESPIRATORY DEVICES

A respiratory device is one of the most important pieces of equipment for all pesticide applicators. It will serve you well to own these protective devices and know how to use and care for them properly.

Specific types of cartridges and canisters protect against specific chemical gases and vapors. Be sure you choose one made and federally approved for use with pesticides.

The two kinds of personal respiratory devices in general use are chemical cartridge respirators and gas masks.

Chemical Cartridge Respirators

Designed most often has half-face masks, respirators cover the nose and mouth, but do not protect the eyes. They have one or two cartridges attached to the face piece by a clamp or similar holding device. These types are usually equipped with one-way valves that allow the inhaled air to pass through the cartridges. There is a separate exhalation valve. These respirators are designed for use where high concentrations of pesticides are unlikely. They are used, for example, when mixing or loading pesticides outdoors with adequate ventilation.

Respirator cartridges usually contain an absorbing material such as activated charcoal. They also have an efficient filter pad to remove dust and spray particles, thus prolonging the life of the absorbent material.

The life of chemical absorbing cartridges or canisters varies according to the concentrations of pesticides encountered. Their effective life is also affected by humidity, temperature, and the volume of breathing.

Tests show that these devices gradually lose their effectiveness during storage because of the exchange of air within the unit due to changes in temperature and atmospheric pressure.

Gas Masks

Designed to supply full-face protection, gas masks cover the eyes as well as the nose and mouth. The face piece of a gas mask may contain a canister of filtering material or it may be connected by a flexible hose to a canister designed to be worn on a belt. Gas mask canisters always contain more absorbent materials and are longer lived than respirator cartridges.

Use And Cleaning Of Personal Respiratory Devices

The following use and cleaning practices are necessary to maintain the equipment's effectiveness in protecting your health.

- The respirator or mask should be fitted properly on the face. Adjust headbands just tightly enough to ensure a good seal. Manufacturers can usually supply special face pieces if the standard one does not fit.
- If you have long sideburns or a beard, you may find it impossible to seal the respirator or gas mask to your face. Shave: don't risk your life for a few hairs!
- Change respirator *filter pads* twice a day or more often if breathing becomes difficult.
- Change *cartridges* after 8 hours of actual use or as soon as any odor of the pesticide is detected.
- Respirators should be cleaned after each use.
- Remove and discard used filter pads, and cartridges and wash the face piece with soap and warm water. Rinse thoroughly in clear water to remove all traces of soap. Dry the face piece with a clean cloth that is not contaminated with pesticide or place the face piece in a well-ventilated shady area (sunlight will eventually ruin the rubber parts). Replace the used cartridges, and filter pads with fresh ones.
- Store the respirator and its freshly replaced parts in a dark, clean, and dry place—preferably in a tightly closed paper or plastic bag.
- Gas masks should be cleaned, have filters changed, and be stored according to the manufacturer's directions.

OTHER RESPIRATORY DEVICES

Self-contained Breathing Apparatus

These respiratory devices do not use filtered air from the surrounding environment. Rather, they come equipped with a cylinder of compressed air which is usually carried on the back. These respirators are especially designed for fumigant work and for applying toxicant gases in enclosed spaces. Self-contained breathing apparatuses are particularly useful in emergency situations such as spills and fires and fumigant leaks. These breathing devices usually contain enough air to supply a person for 30 to 45 minutes.

You should use this kind of respirator:

- When the oxygen in the work area is low.
- When working in high concentrations of very toxic pesticides.

Hooded Respirators

These devices look somewhat like a space suit helmet, and cover the head and shoulders. Usually they are supplied with filtered air blown through the hood by a motorized fan. The units may be powered by a portable battery or they may be powered from the electrical system of the spray vehicle. Some hooded respirators can be air-conditioned for use during hot weather.

Because of their superior protective capacity, supplied-air respirators or gas masks— ***not*** cartridge-type respirators— must be worn when pesticides are formulated or mixed in closed or inadequately ventilated spaces, or when operators are exposed directly to concentrated sprays or dusts, as in greenhouses or indoors. For special operations, such as dusting or spraying a lathhouse, greenhouse, etc., on hot calm days, full face piece gas masks should be used.

Chapter 8

EQUIPMENT AND CALIBRATION

Pesticides are in some cases prepared by the manufacturer in a form that allows their direct application to the target site. For example, snail and earwig baits for home and garden use can simply be poured out of the box. Other pesticide preparations need only be placed in a room or other confined space to control one or another pest. Most pesticides, however, are formulated in such a manner that they require some specialized equipment for application. The application equipment may be as simple as a squirt bottle or aerosol can or it may be as complex as an airplane or helicopter. In any case, successful, efficient and safe application of any pesticide requires that the right equipment for the job be properly maintained and used correctly.

Most pesticides are formulated so that they may be applied using water as the solvent. Since most water-pesticide mixes are applied as sprays, a number of spray devices have been developed. These devices range from simple hand and back-pack sprayers to complicated and powerful air-blast units capable of holding hundreds of gallons of solution. Each device has its uses and limitations. This discussion of pesticide application equipment includes descriptions of the devices, their uses, their advantages and disadvantages.

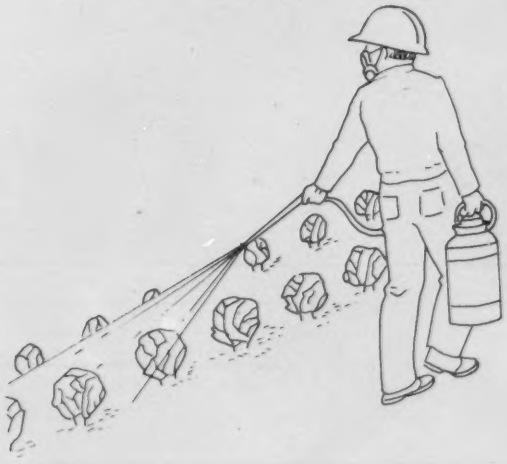
TWO BASIC CATEGORIES OF APPLICATION DEVICES

The type of application device to be used for a specific job should be selected after careful consideration of the location to be treated and the pest to be controlled. Generally speaking, there are two basic categories of application equipment—unpowered and powered.

Unpowered Applicators

An unpowered applicator usually consists of a small metal container holding a few gallons of solution or pounds of dust or granules. If the pesticide is a spray it is usually added to the container, diluted with water, and the unit pressurized by pumping air into the canister. Other types of hand sprayers are aerosol bombs, and granular applicators. Hand applicators are generally used to apply pesticides in structures, for small jobs around homes and gardens, and in areas where powered units cannot be used.

- Advantages: Hand sprayers are inexpensive, simple to use and easy to clean and store. They are popular among homeowners, gardeners, and others who apply small amounts of pesticides on an irregular basis.



- Disadvantages: They are small and only small areas can be treated. They require constant agitation to keep some formulations in suspension. They may be clogged by wettable powders.

Power Applicators

A power applicator is used for most larger pesticide applications. Power equipment makes possible the efficient and rapid application of pesticides to large areas. With power equipment the pesticide can be

sprayed over many acres of a field crop in a day's time, be blown to the tops of tall trees, or forced into confined spaces.

Most power sprayers are designed to apply pesticides in a diluted form. The concentrate is mixed with a solvent, such as water or oil, and pumped from a storage tank through distribution lines to one or more nozzles which control the size and distribution of the spray droplets. The details of this machinery vary in complexity, capabilities, and cost.

TYPES OF POWER APPLICATORS

There are many kinds of powered application equipment, including foggers and aerosol generators, dusters, granule spreaders, low pressure boom sprayers, high pressure sprayers, air blast sprayers, low volume and ultra low volume concentrate sprayers, and aircraft.

Foggers And Aerosol Generators

These break the pesticide formulation into very small droplets. The large number of particles are visible as a cloud of fog. The fog may be created by atomizing nozzles, spinning disks or high pressure nozzles, or it may be made by a heated element called a thermal generator. These devices fill the target area with a pesticide cloud which kills pests on contact.

- Advantages: This equipment produces very fine droplets which do not stick to surfaces within the area. The droplets penetrate cracks and crevices and kill pests in flight.
- Disadvantages: There is little residual control. Long distance drift may cause unwanted contamination; even light wind may be a problem. Special formulations are required.

Dusters

These applicators blow fine particles of the pesticide formulation onto the target.

- Advantages: Dusts are generally ready to apply as supplied by the manufacturer. They do not require water.
- Disadvantages: Dusts are highly subject to drift. They are expensive. They do not always give good coverage of foliage.

Granule Applicators

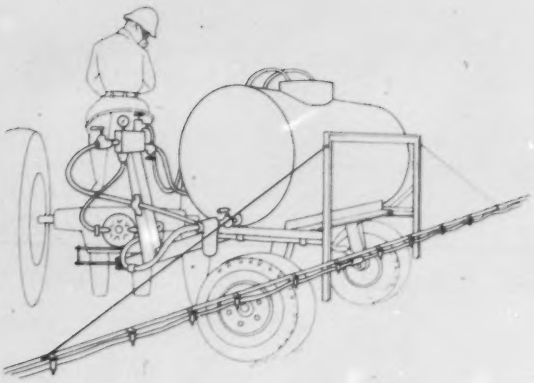
These devices are designed to apply coarse, dry particles that are uniform in size to soil or water.

- Advantages: Granular spreaders eliminate the necessity of mixing the formulation with a solvent. The equipment is relatively inexpensive. There is little drift hazard. The granules themselves are less hazardous to the applicator. Existing equipment (such as seeders) can often be modified to spread granules.
- Disadvantages: the granular form of the pesticide is relatively expensive. Granular spreaders require re-calibration for each formulation. Granular equipment gives poor lateral distribution on side slopes. Granules do not usually stick to foliage and therefore will not control most leaf-feeding insects.

Low Pressure Boom Sprayers

These sprayers are usually mounted on tractors, trucks, or trailers. They are designed to deliver low to moderate volume at 30-60 pounds per square inch (psi). They deliver a relatively low volume of dilute spray ranging from ten to forty gallons per acre. A great many low pressure boom sprayers are used to treat field and forage crops, pastures, and rights-of-way.

- Advantages: Low pressure boom sprayers are relatively inexpensive. They are light weight, have enough capacity to cover large areas, and may be adapted to many uses.
- Disadvantages: Low pressure boom sprayers are not useful when high volume is required because their rate



of application is low. They cannot penetrate dense foliage because they operate at low pressure. Most low pressure boom sprayers agitate the formulation with a bypass system which may not give adequate agitation to prevent wettable powders from settling out; mechanical agitators are available.

Ultra Low Volume Sprayers (ULV)

These sprayers apply the chemical concentrate directly without the use of water or any other liquid carrier.

- Advantages: The main advantage of ULV sprayers is the labor and time saved due to the elimination of water.
- Disadvantages: There is an increased risk to the applicator from handling and spraying the pesticide concentrate. There are only a limited number of pesticides registered for ULV application at the present time.

COMPONENTS OF POWER APPLICATORS

Tanks

The tank of a power sprayer holds the pesticide and diluting solvent. The tank also generally contains some sort of agitation device designed to keep insoluble formulations (e.g., wettable powders) in suspension. Tanks may be made of almost any material from wood to stainless steel, but those made of corrosion and rust resistant materials are longest lasting, easiest to clean, and least expensive in the long run. The tank should have a large opening for easy filling and cleaning; it should be equipped with a good drain, screens and filters to protect the pumps. The tank is required by regulation to have an easy-to-read accurate sight gage or other external means of determining the internal level. As an alternative, the fill hose can be equipped with an automatic back pressure shut-off device. The opening of the tank should be fitted with a cover that can be secured enough to prevent spills or splashes. The drain should open through the bottom of the tank so that the tank can be emptied completely.

High Pressure Sprayers

These are often called "hydraulic sprayers." They deliver large volumes of spray at pressures up to several hundred psi. high pressure sprayers are used to spray fruit trees, shade trees, and ornamentals. They are also used to spray vegetables, livestock, orchards and structures.

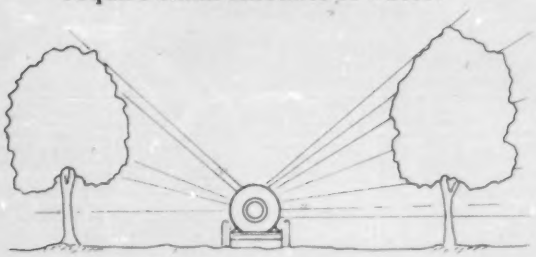
- Advantages: High pressure sprayers are more versatile than low pressure units. They can deliver very large volumes at pressures high enough to penetrate dense foliage, thick hair on livestock, or reach the tops of tall trees. They are usually well built, often have mechanical agitation and resist wear.

- Disadvantages: The high pressure sprayers are expensive. They are heavy and they require large amounts of water and fuel. Because the spray is produced at high pressures, there is a tendency for it to form small droplets which may drift.

Air Blast Sprayers

These are used to treat orchards and shade trees, vegetables and for fly control. These units use a high speed, fan-driven air stream to disperse the spray. A series of nozzles inject the spray into the air stream which breaks up the droplets and blows them into the tree. They can deliver either high or low volumes of spray.

- Advantages: The air blast sprayers give good coverage and penetration. They use low pump pressures and have mechanical agitation. They can be operated at low volumes and therefore require small amounts of water.



- Disadvantages: The air blast sprayers may produce small droplets, which may create a drift hazard. They must be used under calm weather conditions. They are difficult to use in small areas, and it is hard to confine the discharge to the target.

Low Volume Air Sprayers

These sprayers, often called mist blowers, are characterized by high air velocities and somewhat lower water volumes than con ventional air-blast sprayers. This type of sprayer depends on a metering device which may or may not be a conventional nozzle, that operates at low pressures and depends on the high speed air for liquid breakup.

- Advantages: A considerable saving in time and labor is possible with low volume sprayers because less water is handled than with conventional air-blast sprayers.
- Disadvantages: Calibration is critical with low volume air sprayers and favorable spraying weather is essential. Coverage with low volumes on some crops may be less satisfactory than with normal volumes.

Agitators

Many pesticide formulations require continuous agitation to keep the materials evenly distributed in the solution. Without agitation the insoluble parts of the formulation will settle to the bottom of the tank where they will clog lines, become caked, or change the concentration of pesticide in the material being applied.

Agitation may be accomplished by hydraulic or mechanical means. Hydraulic agitation is achieved by pumping some of the solution back through the tank. The solution flows through a series of nozzles located near the bottom of the tank. This type of agitation is satisfactory when used in relatively small tanks. For larger tanks, a "jet agitation" system is more suitable. This more elaborate hydraulic agitation system includes a special pump to provide high pressure flow through the system.

Hydraulic agitation systems cause problems if the pump is shut off, even for a very brief time. The insoluble portion of the formulation may settle to the bottom and require mechanical agitation before the hydraulic system will again be effective.

Mechanical systems achieve agitation through the use of some sort of paddle or propeller suspended in the spray tank. Mechanical devices are initially expensive and harder to maintain, but they assure continuous and thorough agitation.

Pumps

The pump is the heart of the sprayer. There are many types of pumps available

for pesticide application equipment. Each type of pump has its advantages and disadvantages, but any pump should be adequate for all the spraying pressures you intend to use.

When selecting a pump, you should consider:

- *Capacity.* The pump should be of sufficient capacity to supply the output to all nozzles plus about 50% more for the hydraulic agitation system if there is one. Pump capacities are given in gallons per minute (gpm) or gallons per hour (gph).
- *Pressure.* The pump must be able to produce the desired operating pressure at the capacity required for the spraying job. Pressure is measured in pounds per square inch (psi).
- *Resistance to corrosion and wear.* The pump must be able to tolerate the chemicals without excessive corrosion or wear.
- *Repairs.* Choose a pump that is designed so that repairs can be made economically and quickly.
- *Type of drive.* The pump should be readily adaptable to the available power source.

Types of Nozzles

The nozzle is perhaps the most important single element in the mechanical system you use to apply a pesticide. The nozzle helps control the rate, drop size, uniformity, thoroughness, and safety of the pesticide application. All your efforts in identifying the pest, selecting a material to apply to the pest, and properly applying the chemical can be a total waste if the nozzles are not correctly selected, installed, and maintained.

Nozzle performance is the key to effective and efficient performance of the entire sprayer system. To maintain effective nozzle performance, you should remember that nozzles are precision devices which must be cleaned, kept in good repair, and properly adjusted.

The actual operating characteristics of any spraying system depend upon the following factors:

- Nozzle type
- Nozzle size
- Nozzle condition
- Nozzle orientation
- Nozzle spacing on the boom
- Nozzle elevation above the ground

Various nozzles are available, and they are designed to do a great many jobs. Anyone wishing to obtain efficient results should understand the basic types of nozzles and their construction.

Flat fan. This nozzle produces a nearly flat fan in several selected angles and deposits a flat, oval pattern on the ground. The outer edges of the deposit are of reduced volume, which permits the fan patterns to be overlapped to produce uniform coverage. (Nozzle spacing on the boom and elevation above the ground are prime factors in producing the desired uniform application.) These nozzles are used for broadcast or boom spraying in weed control work.

Even flat fan. This nozzle fills the outer portions of the spray pattern to produce even coverage across the entire width of the pattern. It is not designed for overlapping use on a boom. It is efficient for coverage of a given strip through the field as over a crop row. It is generally best for band spraying of herbicides in row crop work.

Cone. These nozzles spray in a cone pattern, either as hollow cones or solid cones. The cone angle contributes to better coverage of foliage and is most popular in insect and disease control work. *Hollow cones* are designed for moderate to high pressures and are used where thorough coverage of crop foliage and uniform distribution is desired. There is little or no spray in the center of the pattern. *Solid cones* are used for hand spraying, spot spraying, and moderate-pressure foliar applications. The spray is well-distributed throughout the pattern.

Flooding or impact. These nozzles may be used for herbicides and fertilizer solutions.

They normally operate at low pressures with large droplets and can cover a wide area, so that it may be unnecessary to use a boom. This is an advantage on rough terrain or where many obstacles would hinder boom operation.

Offset. These nozzles lack the uniformity of the flat fan but can provide reasonably uniform coverage over wide areas for roadside and ditchbank weed control.

Atomizing. These nozzles make a fine mist from liquid pesticides, and are used indoors in special situations.

Broadcast. These nozzles are used on boomless sprayers and to extend the effective swath width when attached to the end of a boom. The spray is in a wide flat fan pattern.

Solid stream. These nozzles are used in handguns to spray a distant target, and for crack and crevice treatment in buildings. They are also used in nozzle bodies to apply pesticides in a narrow band or to inject them into the soil.

Nozzle Construction and Use

Nozzles are subject to wear; they must be replaced before excessive wear occurs or they will fail to deliver the accurate amount and pattern of spray. The rate at which a nozzle wears depends upon several factors including: (a) the formulation of the material sprayed; (b) the nozzle design; and (c) the material used to construct the nozzle. Some nozzle materials used are:

- *Brass*—inexpensive; wears quickly from abrasion; good for limited use.
- *Stainless steel*—will not corrode; resists abrasion; relatively expensive.
- *Aluminum and Monel*—resist some corrosive materials.
- *Plastic*—resists corrosion; swells when exposed to some solvents; inexpensive; not recommended for high pressure spray applications.
- *Tungsten carbide and ceramic*—highly resistant to abrasion and corrosion; expensive.

In buying and using a nozzle it is important to keep the following information in mind:

- Select a nozzle that will provide the desired droplet size, volume of flow, and pattern.
- After installation, properly calibrate the system to ensure that, in all respects, it is applying uniform coverage at the desired rates.
- Provide the nozzle with a material free of foreign particles, and provide it at a properly regulated pressure.
- Mount the nozzles so that their location, relative to the target, is maintained constantly and properly.
- Move the nozzles through the field at constant speed to ensure uniform application rates.
- Maintain the system in peak condition by periodic inspections and calibrations; pay particularly detailed attention to the performance of each nozzle.

Sprayer Maintenance

Most trouble with sprayers can be traced to foreign matter that clogs screens and nozzles and sometimes wears out pumps and nozzles.

WARNING

Never use a pocket knife or other metal object to clean a nozzle. It will damage the precision-finished nozzle edges and ruin the nozzle performance. A round wooden toothpick is much better. Better still, remove the nozzle tip and back-flush it with air or water first before trying anything else. Don't blow through it by mouth.

Pump deterioration is brought about by ordinary use, but it is also accelerated by misuse. The following suggestions will help minimize labor problems and prolong the useful life of the pump and sprayer.

1. *Use clean water.* Use water that looks clean enough to drink. A small amount of silt or sand particles can rapidly wear pumps and other parts of the sprayer system. Water pumped directly from a well is best. Water pumped from ponds or stock tanks should be filtered before filling the tank. To avoid contamination of water supplies, regulations require that the application equipment be equipped with an air-gap separation or backflow prevention device to prevent pesticides from being siphoned back into the water source.
2. *Keep screens in place.* A sprayer system usually has screens in three places: a coarse screen on the suction hose; a medium screen between the pump and the boom; and a fine screen in the nozzle. The nozzle screen should be fine enough to filter particles which will plug the tip orifice.
3. *Use chemicals that the sprayer and pump were designed to use.* For example, liquid fertilizers are corrosive to copper, bronze, ordinary steel, and galvanized surfaces. If the pump is made from one of these materials, it may be completely ruined by just one application of the liquid fertilizer. Stainless steel is not adversely affected by liquid fertilizers, and pumps made from this substance should be used for applying these types of fertilizers.
4. *Never use a metal object to clean nozzles.* To clean, put on rubber gloves and then remove the tips and screens and clean them in water or a detergent solution using a soft brush. The orifice in a nozzle tip is a precision machined opening. Cleaning with a pin, knife, or other metallic object can adversely change the spray pattern and capacity of the tip: if no brush is available, use a round wooden toothpick.

5. *Flush sprayers before using them.* New sprayers may contain large amounts of metallic chips and dirt from the manufacturing process. Sprayers which have been idle for a while may contain bits of rust and dirt. Put on rubber gloves and then remove the nozzles and flush the sprayer with clean water. Clean all screens and nozzles thoroughly before using the sprayer.
6. *Clean sprayer thoroughly after use.* After each day's use, thoroughly flush the sprayer with water, inside and out, and operate the pump to clear lines and nozzles to prevent corrosion. Be sure to wear rubber gloves if it is possible that your hands will make contact with remaining pesticide material during the flushing process. Also be sure to discharge cleaning water where it will not contaminate water supplies, streams, crops, or other plants and where puddles will not be accessible to children, pets, livestock, or wildlife.

Additional Parts Of The Spray System

Power spray equipment is a complex system of parts, each of which must operate properly for the entire system to work efficiently. You should rely on your own judgment and the advice of experts such as farm advisors and manufacturer represen-

tatives for details on the selection, maintenance, repair, and replacement of hoses, strainers, valves, flowgages, pressure gages and regulators, as well as for tanks, pumps, and agitators.

WHY CALIBRATE?

It is important to calibrate application equipment to ensure that you are applying the correct amount of pesticide. You cannot tell by looking when you have applied a proper dosage. Efficient and legal use of pesticides requires accuracy in application rate: ***you must calibrate your sprayer to achieve this accuracy***, for your own protection and that of other people, livestock, pets, wildlife, crops, and the environment as a whole.

Calibration Of Pumping Rate (In Gallons Per Minute)

To find the pumping rate of any sprayer, you must find the amount of spray being pumped through the nozzles each minute. Fill the spray tank completely full of water. Close the tank. Then, with the vehicle in neutral and the throttle setting you have chosen (which is the same setting you will use for the actual application), open the valve. Let the sprayer pump for 5 full minutes. (The reason for using 5 minutes is to get a more exact measurement: the amount, for example, sprayed in one minute may be too small to measure accurately.) Close the valve, shut down, and measure the amount of water needed to refill the tank. Divide this figure by 5 to find the amount the sprayer pumps in one minute.

$$\frac{10 \text{ gallons}}{5 \text{ minutes}} = 5\overline{)10}\,\,2 = 2 \text{ gallons per minute}$$

To find the pumping rate of an air blast sprayer or a mist blower, completely fill the blower tank with water. Then bring the blower up to operating speed and pressure. Open the valve, run it for 5 full minutes, then close the valve and shut down. Repeat as above.

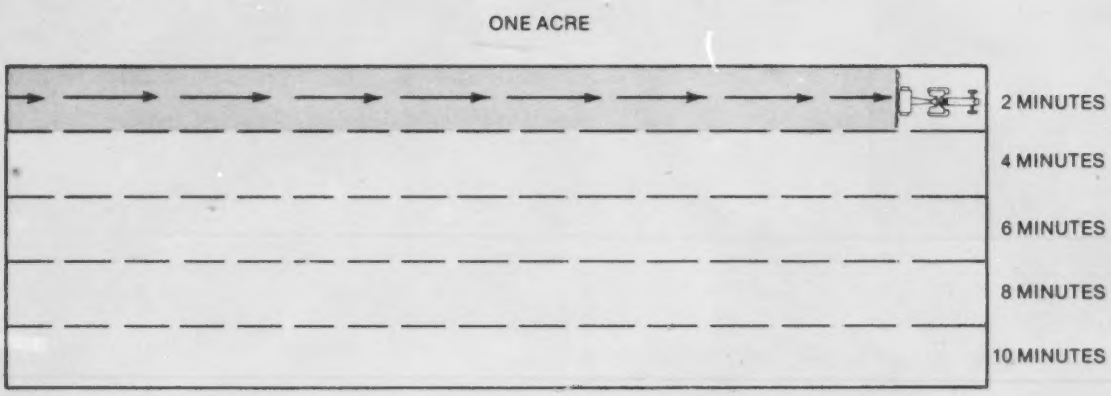
Required Conditions Of Field Sprayer Calibration

You need to know more than the pumping rate when a small amount of pesticide must be applied accurately and evenly to a relatively large area, as when you are treating a field with an herbicide at the rate of one-half (0.5) pound per acre of actual pesticide (active ingredient). This job is usually done with a tractor- or truck-mounted sprayer equipped with a boom having several nozzles. In order to apply the pesticide evenly and accurately, you must:

- Move your sprayer at a constant speed over the field.
- Be sure the sprayer is pumping at a constant pressure.
- Choose the speed, pumping pressure, and nozzles that you wish to use (and keep all three of these factors constant during calibration of the sprayer and the application which follows).
- Be sure each nozzle is clean and at the proper height from the ground. Measure nozzle output to be certain that each nozzle is applying the same amount of spray.
- Calibrate your sprayer so that you know the total amount of spray it will apply to an acre.
- Calibrate your sprayer under actual spraying conditions (field—not pavement).
- ***Remember:*** Just because the sprayer was calibrated once doesn't mean it will always be calibrated.

Calibration Of A Field Sprayer—Without Arithmetic

There is an accurate way to calibrate your sprayer without having to do any calculations. First, mark out an acre, that is, an area 440 feet by 99 feet. For calibration purposes, you may also measure an acre as a square area 209 feet on a side, or a rectangular area 436 feet by 100 feet, or a similar area marked off and totalling one acre. Then fill the spray tank with water and spray the acre, moving at the same constant speed (same throttle setting) as if you were applying the pesticide. When you



20 FOOT BOOM
220 FEET PER MINUTE TRAVELED
2 GALLONS PER MINUTE PUMPED
10 MINUTES PER ACRE x 2 GALLONS PER MINUTE = 20 GALLONS PER ACRE

have finished spraying the acre, measure the amount of water needed to refill (top off) your tank: this amount is your rate per acre. For example, if it takes 12 gallons to refill the tank, then you are spraying at the rate of 12 gallons per acre. (***Warning:*** Do not change speed when you apply the pesticide. If you slow down, you increase the gallons per acre; if you speed up, you decrease the gallons per acre. Any change in speed can negatively affect control of pests or pesticide residues.)

Calibration Of Gallons Per Acre—With Arithmetic

You may not wish to spray over a whole acre to calibrate your equipment. It is not necessary if you are willing to learn a few basic facts and do some simple figuring. One method of calibration is shown below (there are several other methods). The facts you must know for this method are:

1. One acre = 43,560 square feet
2. The distance your sprayer moves in one minute at the throttle setting you are using.
3. The width of your spray boom.
4. The pumping rate of your sprayer. (see: *Calibration of Pumping Rate*).

Example: Suppose your sprayer's boom is 20 feet wide, that it travels 220 feet in one minute, and that it pumps 2 gallons each minute.

Figure the area that the sprayer covered in one minute (the distance traveled multiplied by the boom width);

220 feet per minute × 20 feet = 4400 square feet per minute

Then figure how many minutes it would take to spray one acre. One acre = 43,560 square feet. Divide 43,560 square feet/acre by 4400 square feet/minute.

$$\frac{43{,}560 \text{ sq. ft./acre}}{4400 \text{ sq. ft./minute}} = 4400\overline{)43560}\ 9.9 = \text{about 10 minutes/acre}$$

$$\begin{array}{r} 39600 \\ \hline 39600 \\ 39600 \end{array}$$

Finally, figure the amount of spray pumped per acre.

2 gallons/minute × 10 minutes/acre = 20 gallons/acre

How Much To Put In The Tank?

You know how much spray the system puts out per acre treated. To figure out how much chemical to put into the tank, you also need to know two additional facts: the amount of chemical called for by the label or recommendation and the amount of water the tank holds. Here are a few suggestions for obtaining these facts.

1. Amount of chemical: read the label. Determine the correct amount of pesticide to apply to the crop or target to

control the specific pest. Label recommendations are your first source of information concerning application rates; additionally you may have a written recommendation from an agricultural pest control advisor or farm advisor.

2. Amount of water: There are three ways to measure tank capacity.

   Dip stick method. Empty the tank and level it. Fill the tank with water, using a container such as a five gallon can. As you fill the tank, mark convenient quantity levels on a dip stick. As you do this, be certain that the dip stick goes into the same part of the tank each time you make a measurement. You may wish to mark the dip stick at intervals greater than 5 gallons. Keep the marked dip stick with the tank, and do not use it for any other equipment.

   Sight gage method. If the tank does not already have one, a simple plastic tube sight gage should be installed. *New regulations require such gages.* To calibrate a newly installed sight gage, park on the level and use the bucket fill method. Mark the quantities on the gage as you fill the tank.

   Flow meter method. If you have an accurate flow meter, you can use it to measure the quantity of water as it goes into the tank. Flow meters are also useful in calibrating the sight gage. *Note:* Flow meters may be inaccurate; test by filling a container of known size.

Now that you know how to obtain the information required—the delivery rate of the sprayer, the amount of active ingredient per gallon of formulation, and the tank and the tank capacity—you are ready to learn how to calculate the exact amount of pesticide to put into the tank.

Example #1: Suppose your tank holds 80 gallons of ready-to-use spray, and you wish to apply one pint of formulation on each acre. You already have found that your sprayer applies 20 gallons per acre.

First find the number of acres one tank load will spray. To do this, simply divide 80 gallons (what your tank will hold) by 20 gallons per acre (what your sprayer applies).

$$\frac{\text{80 gallons per tankful}}{\text{20 gallons per acre}} = \text{4 acres per tankful}$$

Then find the amount of formulation you must add to your tank, so you can spray 4 acres with one pint per acre. Multiply 1 pint per acre by 4 acres (the number of acres one tank load will cover).

$$\text{1 pint/acre} \times \text{4 acres/tankful} = \text{4 pints/tankful}$$

Therefore, you must add 4 pints of formulation to each tankful.

Example #2: Suppose the formulation of a pesticide contains 4 pounds active ingredient per gallon and you want to apply ½ pound of active ingredient per acre. Your tank covers 6 acres.

First find how much formulation in pints is needed to apply ½ pound active ingredient per acre. You know there are 4 pounds of active ingredient in 1 gallon. One gallon = 4 quarts. Therefore, there are 4 pounds in 4 quarts and 1 pound in 1 quart. One quart = 2 pints. So there is 1 pound in 2 pints and ½ pound in 1 pint.

$$\frac{\text{4 pounds}}{\text{1 gallon}} = \frac{\text{4 pounds}}{\text{4 quarts}} = \frac{\text{1 pound}}{\text{1 quart}} = \frac{\text{1 pound}}{\text{2 pints}} = \frac{\text{½ pound}}{\text{1 pint}}$$

So, 1 pint contains ½ pound active ingredient.

Then figure how much formulation is needed per tankful. Multiply 1 pint per acre by 6 acres per tankful.

$$\text{1 pint/acre} \times \text{6 acres/tankful} = \text{6 pints/tankful}$$

So you will add 6 pints of formulation to your spray tank in order to apply ½ pound active ingredient per acre.

It is not possible to provide examples for every kind of situation that may arise in the field. For further details on calibration, contact your local farm advisor or other agricultural authority.

Chapter 9

IMPORTANT PESTICIDE USE PROBLEMS

In addition to the safety problems associated with the preparation and application of pesticides, there are several important problems related to pesticide use which should be understood by every applicator. These important problems are drift, phytotoxicity, destruction of beneficial species, resistance, and environmental pollution. With the possible exception of resistance, each of these undesirable side effects occurs when the pesticide enters an environment where it is unwanted. There are many ways in which these undesirable effects can be reduced or eliminated; each depends upon knowledge of the proper handling and use of pesticides, the parts of the environment susceptible to contamination, the pesticides most likely to cause contamination, and preventive measures.

PESTICIDE DRIFT

Drift is a side effect associated with both aerial and ground pesticide applications. Spray drift occurs when some of the airborne particles produced during application of a pesticide dust or spray move away from the intended target. The degree of drift severity depends on such factors as the physical form of the material, how the material is applied, the volume used, and the weather conditions (especially wind and inversion) at the time of application.

Certain pesticide formulations are more likely than others to cause drift during application. Dusts are most likely to drift and granules least likely. Sprays are intermediate in their drift potential, depending on the way they are used.

The equipment and application method employed can affect the amount of drift. When spraying liquid formulations of pesticides, the nozzle and application pressure have the greatest influence on subsequent drift. Improper or worn nozzles or excessive pressures cause the spray to be produced in a form which drifts readily. The rate at which a drop of liquid falls through the air depends upon the size of the droplet. Very small droplets, such as those produced by excessive pressures, fall very slowly. These small droplets can drift for miles before they reach the ground. The method and amount of material applied also influences the hazard of pesticide drift. Small amounts applied by hand from the ground are rarely involved in drift problems. Spray from ground air blast sprayers is highly subject to drift. Aircraft applications of large quantities of pesticides always present the possibility of significant drift.

Applications of chlorinated hydrocarbon pesticides by aircraft have frequently resulted in severe residue problems on forage and feed crops although they were made up to one-half mile or more from the contaminated crop. Other important results of drift are the effects that some chemicals may have on bees, fish, and wildlife when the chemical is carried from the intended point of application by wind.

A second form of drift occurs when pesticides evaporate during and after application. Certain herbicide formulations have been known to cause damage to plants miles from the point of application. A few herbicide formulations may drift as a result of evaporation. A few herbicide formulations may drift as a result of evaporation following application; use of these may be restricted in many areas.

Drift should be avoided because:

- It wastes expensive pesticides.
- It spreads pesticides into the surrounding environment where they may cause illegal residues, health problems, damage to wildlife, and other undesirable effects.
- It can damage sensitive crops.
- It has been the subject of a great number of damage claims for crop losses.

Drift can be a severe problem and should be taken into consideration before making any type of pesticide application.

PHYTOTOXIC EFFECTS OF PESTICIDES

Phytotoxicity is the injury or death of a plant due to exposure to some chemical. Plants may be injured or killed by exposure to salts, fertilizers, or pesticides. Sometimes this plant injury is intentional, as when an herbicide applied to a weed. In other cases the plant injury is an accidental side effect of pesticide use. Phytotoxicity can effect any part of the plant—roots, trunk, foliage, blossoms, or fruit.

The degree of phytotoxic effect may vary in response to a number of factors. Some toxicants (active ingredients) are particularly damaging to plants. Other inert components of the pesticide mixture, such as the solvent, may cause plant damage. The plants themselves may vary in susceptibility to injury by various chemicals. The phytotoxic reaction may vary with the species of plant, with the age of the plant, or with the weather at the time of exposure.

The manner in which the chemical is applied may determine whether or not injury will occur. For example, excessive pressures while spraying may cause physical injury to the plant or drive the chemical into the plant tissues. The chemical concentration may affect phytotoxicity: excessive concentrations may cause plant damage.

Mixing pesticides may cause phytotoxic reactions. Certain pest problems require the combination of two or more chemicals and this may often be done successfully. However, certain chemicals are not compatible with others and one of the results of this incompatibility may be severe phytotoxic response.

Always check the label for warnings or precautionary statements regarding chemical compatibility, timing of application, weather precautions, application interval, and phytotoxicity before using the pesticide.

DAMAGE TO BENEFICIAL INSECTS

The efficient production of many crops including fruits, vegetables, forage, and seeds would not be possible without the activities of bees and other pollinating insects. In California the beekeeping industry maintains 500,000 colonies; each year honey bees pollinate $300 million worth of crops in the state.

For over 80 years the honey bee industry has sustained serious losses from pesticide applications; in some recent years nearly 100,000 colonies have been lost due to pesticides. Losses of wild species of pollinating insects are difficult to document, but they are thought to be considerable.

Successful agriculture in California requires pesticides to control many agricultural pests, yet bees are also required for pollinating about one-third of our agricultural crops. Since this is so, we must learn how to use pesticides so that pests are controlled and beneficial insects survive.

There are many cases in which pest species are present but do not cause significant damage because of the presence of beneficial species which help reduce the pest populations. When pesticides are applied to control a certain pest, beneficial parasites and predators also may be killed off. As a result the pest species population may increase until it causes significant damage. This type of problem is of particular importance in insect control.

The ideal pesticide is selectively non-toxic to bees and other beneficial insects while controlling a specific pest. Few products meet this ideal; in each case the best compromise must be found.

The pesticide applicator should consider the presence and importance of beneficial species before choosing a pesticide. Some pesticides are especially hazardous to beneficial species, while others are less so. ***Be informed before you make any application.***

PROTECTION OF BEES

Bees are insects, and therefore are readily poisoned by many common pesticides.

When a pesticide known to be harmful to bees is used on crops where honey bees are working, special procedures must be followed. Under California law beekeepers may request notification of intended pesticide usages, and the applicator is required to provide such notice. It is the applicator's responsibility to inquire of the County Agricultural Commissioner if any beekeeper has requested notice of pesticide applications on the property where the beehives are held or within one mile of such property. If the beekeeper has requested notification, the pesticide applicator must notify the beekeeper in a reasonable time, so that the beekeeper may move, cover, or in some way protect the bees. In this notification, the applicator must inform the beekeeper of the time and place the application is to be made, the crop and acreage to be treated, and the identity and amount of the pesticide to be applied.

In some areas centralized private organizations operate a beekeeper notification program. Bee notification maps are maintained and each day copies of beekeepers' requests for notification from the County Agricultural Commissioner are received. Then interested beekeepers are notified by a single telephone call of all intended applications within one mile of their hives.

RESISTANCE TO PESTICIDES

Resistance is one of the most important side effects of the use of pesticides. Resistance means the development of a strain of organisms able to tolerate doses of pesticides which would prove lethal to the majority of individuals in a normal population of the same species. In some cases it may be practically impossible to kill the pest with a pesticide which only a few years earlier was specifically recommended for that pest.

Resistance develops when a recommended pesticide kills the majority of the pests contacted but does not kill a few individuals, who survive because they have some internal defense mechanism which makes them immune to the poison. In a newly exposed population there may be only a few survivors, but it is these survivors who live to reproduce and pass on the resistance factors to their offspring in the following generations. Generally the few survivors look and behave exactly like the susceptible insects, but they have an increased immunity to the pesticide.

If the pesticide is used frequently the pests are subjected to continuing "selective pressure;" within a few generations most of the individuals in the population are the offspring of resistant parents and are themselves resistant.

Soon after World War II, DDT and other new pesticides came into widespread use. Many cases of resistance were observed. By 1966, some 180 species of pests were reported to be resistant to one or more pesticides. By 1975, between 250 and 300 species were reported to be resistant. Most examples of pesticide resistance are found among insects. Only a few cases of plant resistance to herbicides have been observed. Theoretically, however, resistance may develop in any pest population.

When a pest population becomes resistant to one pesticide it may also become resistant to other chemically-related pesticides not previously used. This is called *cross-resistance.* Cross-resistance happens because similar or closely related pesticides all have the same effect on the physiology of the pest. In other words, the related pesticides kill in the same way or by the same mode of action. The defense mechanism of the resistant pest is therefore effective against the new as well as the old pesticide.

There are a number of serious consequences of resistance. Among these are the loss of effectiveness of the pesticide, and the difficulty in finding alternative pest control practices. Frequently substitute materials are not available, and when they are they are often more expensive. At times extensive damage occurs before substitute materials are found, tested, and registered for use against the pest. And finally, in some cases, the problem of resistance has become so severe that the major crop of a particular area can no longer be grown successfully. In a few areas severe econo-

mic disruptions have occurred as a result of the development of pesticide resistance.

Recognizing Resistance

You should realize that not all pest control failures are the result of resistance. Improper pest control practices may be at fault. However, if the material was timed and applied properly at the recommended rate and no other important factors (such as unfavorable weather) have interfered with the pesticide, resistance should be considered.

Early signs of resistance may sometimes be recognized in the field. These include increasing difficulty in controlling a pest, increasing damage by a formerly minor pest, decreasing yields, and increasing trouble with insect-transmitted diseases.

Developing resistance can be very subtle and may go unnoticed for a time; it may appear in only part of a field or only in a few fields. Suspected resistance should be reported to agricultural authorities in the area, since early detection may make it possible to avoid extensive losses.

Delaying Resistance

Resistance in pest populations results from repeated exposure to a pesticide. One method of delaying the development of resistance is to avoid the use of pesticides whenever possible. This can be done by using available non-chemical methods as the primary means of control, with chemical pesticides applied only as a supplement when necessary. Treatments on a predetermined schedule should be avoided and chemicals applied only when infestations reach levels threatening or causing damage. Rotating pesticides between organophosphates and carbamates may help delay the onset of resistance.

UNWANTED ENVIRONMENTAL EFFECTS

Unwanted pesticide chemicals in air, soil, water, and vegetation are one form of environmental pollution. In a broader sense, the accumulation and storage of pesticides in plants and animals can also be considered a form of environmental pollution.

As the population of the world increases, our environment is becoming more and more polluted; the increased use of pesticides contributes to this condition. Care in the application and disposal of pesticide materials may aid in bringing about a reduction of environmental pollution. In order to accomplish this, those who use pesticides should have an understanding of the fate of these chemicals after they have been released into the environment.

Whenever pesticides are used some percentage fails to reach the target. Furthermore, the material eventually reaches the general environment in either its original form or in the form of some breakdown product. Each pesticide has its own unique chemical and physical properties and therefore its own unique behavior in the environment. However, when the effects of pesticides on the environment are considered as a whole, it is possible to make a few generalizations.

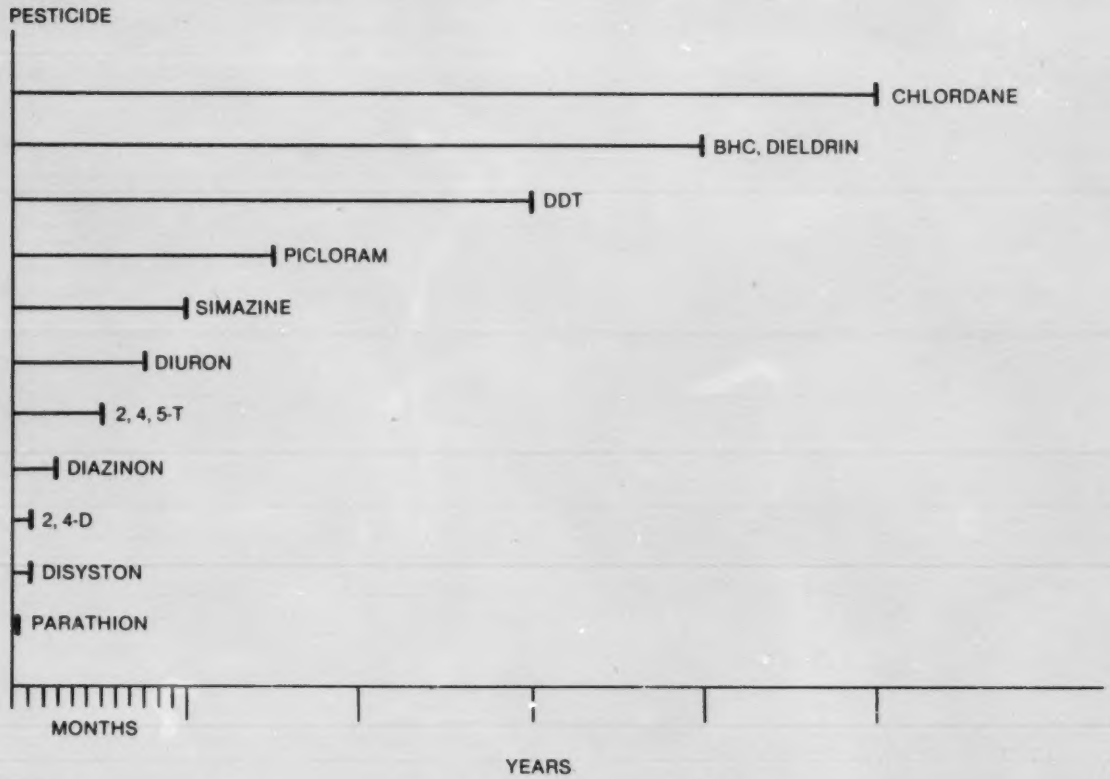
Atmospheric Pollutants

Pesticides may enter the atmosphere by several methods. They may be blown away from the target area during application. They may evaporate and drift from the surfaces of plants, animals, and the earth. And they may be blown away with soil particles and smoke from burning materials. A major source of atmospheric pesticide pollution is from improper application of sprays and dusts. Spraying during windy periods or with the wrong or improperly maintained equipment are major contributors to this problem. Once in the atmosphere, pesticides are either degraded to other compounds or trapped in particles of water where they finally fall to earth.

Soil Pollutants

Most pesticides are applied to plants. Whenever pesticides are used on crop plants, a great percentage of the material reaches the ground during the application or when harvest residues are incorporated

PERSISTENCE OF INDIVIDUAL PESTICIDES IN SOILS



into the soil. Pesticides may also be applied directly to the soil to control insects, weeds, fungi, and nematodes. In this case most of the material reaches the ground immediately and in unchanged form; then it may be incorporated into the soil through agricultural operations.

Pesticides also reach the soil as fallout from atmospheric pollution. When excess or repeated applications of inorganic or very persistent organic pesticides are made, soil residues can build up until they become a severe problem. Residues of hundreds of pounds per acre have accumulated in some soils. Pesticides in the soil may cause illegal residues in root crops or they may be translocated into the tops of plants. They may also leach into nearby water supplies or cause undesired phytotoxicity.

Once in the soil the organic pesticides may be rapidly broken down by natural processes or they may remain unchanged for years. Pesticides in soils break down through various reactions, which depend on the chemistry of the soil, its moisture content, its pH, and other factors. Many organic pesticides are broken down by the action of microbes in the soil. Microbial decomposition depends on the temperature, moisture, and organic matter in the soil, as well as on the chemical nature of the pesticide itself. Cultural practices can have an important effect on the longevity of pesticides in soils. Proper cultivation and irrigation practices can speed the removal of unwanted pesticides from the soil. Pesticide labels often contain useful information on soil pollution problems associated with the material.

Water Pollutants

Pesticides occur in water as intentional and unintentional additives. Intentional applications are made to control aquatic

organisms including weeds, mosquitoes and gnats, algae, snails, and trash fish. Use of pesticides in water presents special hazards to plants growing in or irrigated with the water, to animals and fish living in the water, and to animals and people who might drink or bathe in the water. Therefore, it is extremely important that those planning to apply pesticides directly to bodies of water ***be completely familiar with the label directions pertaining to any material being used in or around water.***

Unintentional water pollution from pesticides has resulted from drift, drainage from treated soils, accidental applications, unintentional spills, and from sewage effluents. Pesticides in the atmosphere are washed down by rain and reach streams, lakes, and the ocean. Other pesticides reach the surface waters through runoff from soils and from industrial waste disposal. At times pesticides are accidentally sprayed onto bodies of water, where they cause extensive pollution. Such contamination is usually preventable. Spills of pesticides are usually of limited local importance and, because of their emergency nature, are frequently dealt with very effectively. Sewage effluents are generally associated with manufacturing processes and are of little direct concern to the pesticide applicator.

Biotic Pollution

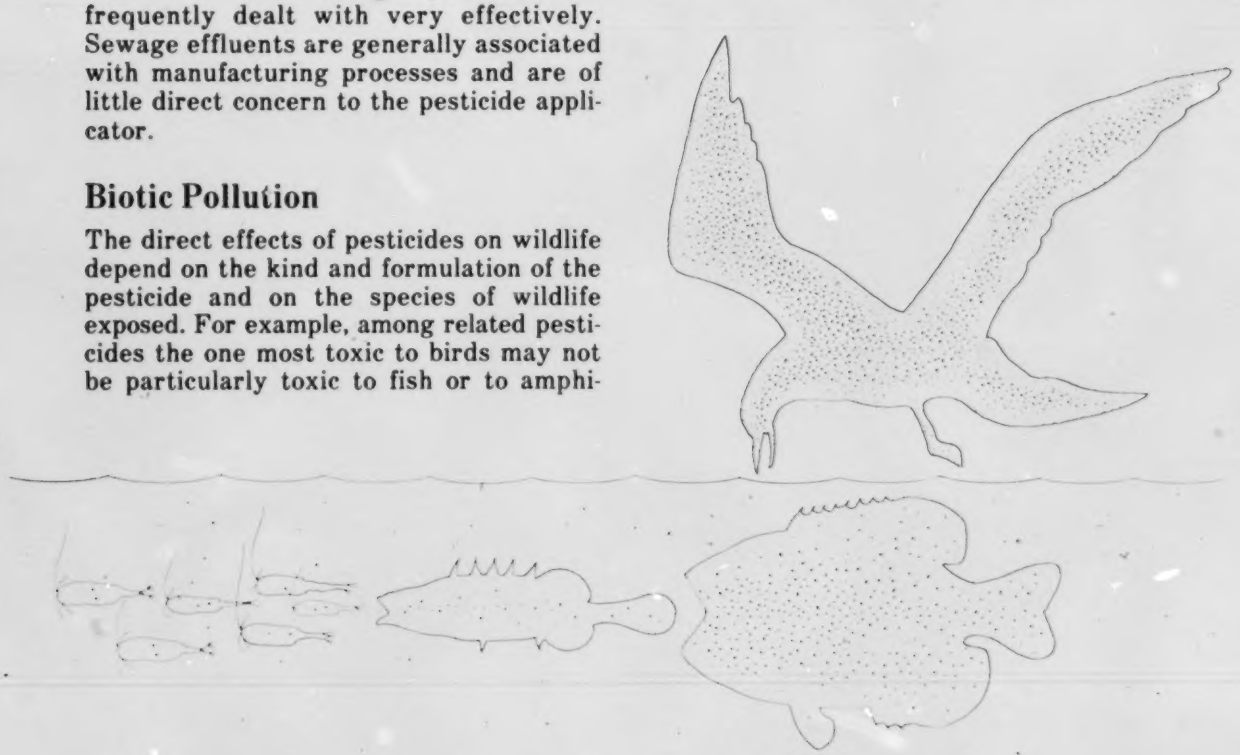
The direct effects of pesticides on wildlife depend on the kind and formulation of the pesticide and on the species of wildlife exposed. For example, among related pesticides the one most toxic to birds may not be particularly toxic to fish or to amphibians. Direct effects on wildlife also depend on the exposure of the animals to the pesticide: pesticides with long residual actions may cause wildlife losses for extended periods. On the other hand, pesticides with short residual effects may cause large losses but only for a short time.

The environment in which the pesticide is used may influence the degree to which wildlife is affected. Pesticides that are not intended for use in water can be particularly damaging when they reach water sources.

These effects should be of concern to all who use pesticide chemicals, and steps should always be taken to minimize the adverse effects of any pesticide usage. Remember: it is illegal to apply pesticides improperly; and it is illegal to apply a pesticide to control a pest unless the pesticide is registered for that use.

Indirect Effects On Wildlife

Some pesticides become concentrated in plants and animals. This well-documented phenomenon is known as *bioconcentration*



and occurs because organisms absorb pesticides directly in pest control operations, from polluted air, soil or water, or through concentration of pesticides in the food chain. The final concentration of pesticides in living things depends on the nature of the pesticide, the kind of organism exposed, and the type of exposure.

One of the major forms of indirect biotic pollution occurs when persistent pesticides —chlorinated hydrocarbons, for example— enter the food chain. The pesticides become more and more concentrated at each higher level in the food chain until, at the highest levels, the pesticide, in concentrations thousands of times higher than its original level in the environment, causes significant biological effects on the contaminated animals.

Minimizing Environmental Effects

While each of us wants to protect the environment, we should also be aware that pesticides, even the persistent and highly toxic kinds, are necessary and useful tools in managing pest populations in both the agricultural and urban environments. Each pesticide label warns you of known environmental effects of the active ingredient. Careful attention to label directions will aid you in the selection and use of all pesticides in ways that minimize adverse environmental effects.

Remember—apply pesticides:

- To an identified pest
- Only when necessary
- Where they are needed
- In recommended amounts
- According to label directions

Chapter 10

PESTICIDE COMPATIBILITY AND COMBINATIONS

When two or more pesticides can be safely mixed, or used in combination, they are said to be *compatible*. Two or more chemicals may be combined to:

1. Increase the effectiveness of one of the chemicals; this is called *synergism*. The manufacturer usually wants to increase the activity of the pesticide formulation against specific pests. This is done by adding a chemical referred to as a *synergist*, which is not an active pesticide but which increases the effectiveness of the pesticide. Synergists usually increase the toxicity of the pesticide so that a smaller amount is needed to bring about the desired effect. This may reduce the cost of application.
2. Provide better control than that obtained from one pesticide. Applicators sometimes combine active pesticides to kill a pest that has not been effectively controlled by either chemical alone. Many combinations are quite effective, but in most cases it is not known if the improved control is a result of a synergistic action or an additive effect of the several chemicals on different segments of the pest population.
3. Control different types of pests with a single application. Frequently, several types of pests need to be controlled at the same time. It is usually more economical to combine the pesticides needed and make a single application. However, the compatibility of the various chemicals must be known before the materials are combined.

When two or more pesticides cannot be used in combination, they are said to be *incompatible*. Some pesticides are incompatible because they will not mix, others because even though they mix, they do not produce the desired results. Some combinations of chemicals result in mixtures that produce an effect opposite to synergism. This effect is called *antagonism* and may result in chemical reactions which cause the formation of new compounds. In other cases incompatibility may result in separation of the pesticide from the water or other carrying agent. If one of these reactions occurs, one of the following may result:

- Effectiveness of one or both compounds may be reduced.
- Precipitation may occur and clog the screen and nozzles of application equipment.
- Various types of plant injury (phytotoxicity) may occur.
- Excessive residues may result.
- Excessive runoff may occur.

Another less familiar but extremely important undesirable effect of combining certain pesticides is potentiation. Some of the organophosphorous pesticides potentiate (or activate) each other as far as animal toxicity is concerned. In some cases, the combination increases the toxicity of a compound that is normally of very low toxicity, so that the result is a compound that is highly toxic to people, other animals, or plants.

The pesticide label will sometimes indicate compatibility problems. Some pesticide formulations are prepared for mixing with other materials and are registered for pre-mixes or for tank mixes. If this is true, it will be so indicated on the label.

When a combination of chemicals is to be made, refer to the compatibility charts that are available through your pesticide dealer or from various other sources.

You should also remember that when one chemical is applied several days after the application of a different chemical, it may result in excessive residue, phytotoxicity, or poisoning of livestock.

Chapter 11

PESTICIDE RESIDUES

Whenever a pesticide chemical is applied, some of the chemical becomes a *deposit* on or in the treated crop, animal or object. The pesticide may remain in its original chemical form or it may be altered chemically by weathering, metabolic degradation or other processes. In any case, with aging of the deposit the quantity of material remaining is called a *residue.* Residues may result from direct application, from drift from nearby fields, from uptake from contaminated soil, or from other sources. In some situations residues are desirable and produce prolonged effective pest control, as in the control of certain public health and structural pests. In other situations, however, residues represent a source of unwanted and illegal contamination—for example, when residues exceed legally determined limits on food or feed crops at harvest.

Residues are usually measured and tolerances expressed in parts per million (ppm) on a weight basis. One ppm is a very small quantity. For example, one ppm is one milligram in one kilogram or one ounce of salt in 62,500 pounds of sugar or one pound of pesticide in one million pounds of raw agricultural commodity. It is possible for an analytical chemist, using the necessary equipment and techniques, to detect some pesticides at levels approaching one one-thousandth (1/1000) part of one part in a million, which is one part per billion (ppb).

The residue levels allowed on food crops at harvest are legally set by the federal and state regulatory agencies and are called *tolerances.* Tolerances are simply the minute amounts of pesticide permitted by the Environmental Protection Agency to be present on or in raw agricultural commodities. These tolerances represent levels of pesticide residues which scientists have determined may safely remain on the food crop without injury to the consumer. Tolerances vary according to the pesticide and the crop.

The State Department of Food and Agriculture and the Federal Food and Drug Administration regularly inspect and analyze samples of fruits, vegetables, feeds, dairy products, meat, and other produce to be certain there is no excessive pesticide residue on food.

You, as a pesticide user, should be aware that pesticide residues greater than the established tolerance are illegal, and agricultural commodities with excessive residues may be seized and ordered destroyed. No pesticide residue is justified or permitted on produce, feeds, dairy products, or any other agricultural commodity unless a tolerance has been established.

In order to be sure that crop residue levels are legal, the pesticide applicator should be familiar with residues and how they occur.

SOME FACTORS AFFECTING RESIDUE LEVELS

Persistence of Compounds

Most pesticides of the chlorinated hydrocarbon group, such as DDT, dicofol, chlordane, endrin, and mirex, are quite persistent. Most of the organophosphate groups, such as TEPP, phosdrin, and parathion, are much less persistent. Most carbamate pesticides are non-persistent. Some factors that influence the persistence of a chemical and the possibility that residues may remain are:

- The amount of chemical applied
- The formulation
- The pH (acidity or alkalinity) of the fill water and of the target tissue.
- The nature of the surface to which it is applied

- Exposure to weathering from wind, rain, etc.
- Chemical breakdown from high temperatures and humidity
- Photochemical reactions from sunlight
- Biological reactions.

If dosages, application techniques, time intervals between application and harvest, milking, or slaughter, and other directions are followed carefully, as specified on the label, there should be no residue on or in the crop in excess of legal tolerances.

Normal kitchen practices or various food processing procedures, such as peeling, washing, and cooking, usually reduce the amount of residues remaining on the food before it is consumed.

Increasing Residues

The loss of water from an agricultural commodity—a process known as dehydration—will usually result in an increase in the percent of whatever residue is present. This is because residues are measured on a weight basis and, if water is removed by dehydration, the article becomes lighter, resulting in a change of the ratio of chemical residue to commodity. In some cases a product may be legal in the raw or green state but illegal after dehydration.

Pesticide Residues From Contaminated Soils

In recent years various federal agencies have conducted extensive studies to monitor pesticide levels in many parts of our environment. Soil, water, fish, and wildlife have been analyzed. These tests have shown that dieldrin, DDT, endrin, BHC, chlordane, heptachlor, and toxaphene are present in variable amounts. It is known that under certain conditions one-half of the toxaphene in soil will still be there 10 years after application. Thus, if toxaphene is applied to a cotton crop and the pesticide reaches the soil, a root crop (such as carrots) planted several years later may become contaminated with illegal residue. If you are farming a new piece of ground, try to obtain a pesticide history of that area before you plant a crop. Keep a history of pesticide applications to your crops: have this history of pesticide use available for your own or the next grower's consideration.

DETERMINING RESIDUES

Many growers and others utilize the services of commercial laboratories that provide residue analysis. The names and addresses of these laboratories are available from the country agricultural commissioner's or local farm advisor's office.

Chapter 12

ALTERNATIVES TO PESTICIDES

Pesticides are useful and necessary tools, widely available and frequently used by almost everyone. They influence our daily lives in dozens of positive ways: they increase our ability to produce food; they help protect us from diseases like malaria and plague; and they help make our general environment a more pleasant place in which to live. Yet pesticides are not without disadvantages. They are expensive; they may themselves create human health problems; they may damage pets and wildlife; they may actually increase our pest problems by suppressing beneficial insects; and they may damage valuable agricultural crops.

Pesticides are a two-edged sword which must be used intelligently: with an understanding of what they can and cannot do, and with respect for their negative aspects.

Pesticides should not be considered the final answer to every pest problem. Many pest problems can be solved efficiently with limited or no use of pesticides by resorting to one of the many alternatives to pesticides.

Some alternative methods of pest control involve techniques probably discovered by some of the earliest humans to engage in agriculture; other alternative techniques employ the most sophisticated scientific thought and devices of this century. Regardless of whether the technique is simple or complex, you as a pesticide user should be aware of these alternatives. Use them whenever you can; in the long run many of them are more effective than pesticides. They frequently cost less; they tend not to damage pets, wildlife, or beneficial insects; and they are less damaging to the applicator, other people, and the environment.

Among the successfully applied alternative techniques for controlling pests are: third generation pesticides, resistant varieties, cultural practices, biological control, attractants and repellents, and genetic control.

THIRD GENERATION PESTICIDES

The third generation pesticides are those chemical and biological agents used and applied in a manner similar to the synthetic organic pesticides, but which are chemically very different from the traditional materials. Because these pesticides are applied like traditional pesticides, they can be used by individuals on small areas such as crops or ornamentals.

Included among the third generation pesticides are the microbial pesticides: bacteria (such as *Bacillus thuringiensis*) and the viruses (such as the nuclear polyhedrosis viruses recently registered for use against several pests). These microbial pesticides, usually sprayed onto the crop, have several important advantages over the traditional pesticide chemicals. They tend to be specific in their action, killing pest species and usually leaving the beneficial insects unharmed; they have very low mammalian toxicity; and they are much safer to handle than many synthetic organic pesticides. However, at this time there are only a few microbial pesticides registered for use.

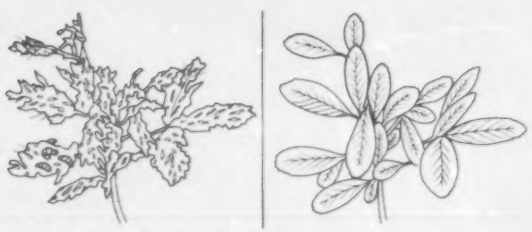
A second example of a third generation pesticide is the Insect Growth Regulator (IGR). These regulators are synthetic organic chemicals which are designed to mimic the action of hormones normally found in every insect. The insect hormones serve as chemical messengers within the body of the insect, signalling it when to change from one developmental stage to another. If an insect is exposed to an external source of these growth regulating chemicals, it is unable to complete its normal development cycle, and eventually the insect dies without becoming an adult. A few IGRs are available for controlling

certain specific pests. They are currently being tested for use against insects invading greenhouses, insects developing in animal droppings, and in forestry.

Synthetic botanicals are a third example of third generation pesticides. These are the pyrethroid chemicals which are similar to the botanical pesticides extracted from chrysanthemums. These promising chemicals are currently being tested against a number of insect pests and will probably become very important in the near future.

RESISTANT VARIETIES

Farmers and horticulturalists can frequently avoid pest problems simply by planting resistant varieties. Plant breeders have discovered and propagated many varieties of plants which are partially to completely resistant to pests. Examples are known of



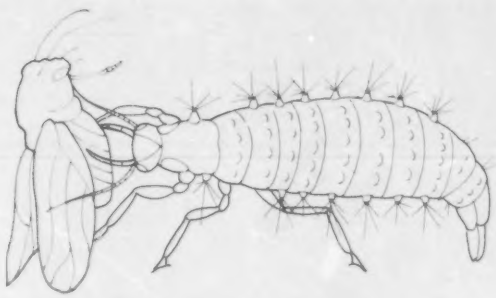
plants which are resistant to insects, fungi, bacteria, viruses and nematodes. Plant breeders are even working to develop plants which are resistant to air pollution. In some cases resistant varieties have resulted in saving an entire crop from massive losses due to insect damage. One classic example of this involved the use of resistant alfalfa varieties when the spotted alfalfa aphid first entered California. Through the development of resistant alfalfa strains, this aphid has become a much less important pest. Whenever possible you should consider using resistant varieties when planting; avoiding an insect infestation is usually easier and less expensive than managing one that has become established.

CULTURAL PRACTICES

Many pest problems can be avoided by careful use of the proper cultural techniques. These are often highly specific techniques, such as field sanitation, which must be applied by the individual grower and must be directed toward the crop-pest complex. Specific information on cultural techniques of pest control should be obtained from your farm advisor or another knowledgable source.

BIOLOGICAL CONTROL

The most widely known method of managing pest species without using chemical pesticides is biological control. Successful



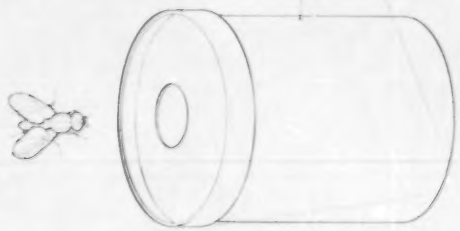
biological control of pest insects, other arthropods, and weeds has been achieved with many species. Several successful applications of biological control have been conducted in California. It was in this state that one of the first and most successful biological control projects was conducted. An imported insect, the cottony cushion scale, was attacking citrus in southern California. The scale became so numerous that the entire citrus industry was threatened. In the 1880s there were no synthetic organic pesticides to protect the crop. After an extensive search, a predatory beetle was found in Australia which attacked the scale. The beetle was imported into the U.S. in 1888, and was released in California citrus groves, where it preyed upon the scale. Within a few years the cottony cushion scale had ceased to be a significant pest in California. Many other examples of the biological control of insects could be given. Similarly, plant feeding insects have been used successfully against pests such as prickly pear, alligator weed, Klamath weed, and tansy ragwort.

Generally, biological control of a pest

requires thorough study of many biological and ecological factors. Some biological control techniques may be available for use by individuals, but, in general, successful biological control of a pest requires large scale testing and developmental programs.

ATTRACTANTS AND REPELLENTS

Attractants and repellents offer promise of helping control pests. In some cases chemicals may be used to attract pests to traps where they are killed. In general, however, attractants are not particularly effective in managing pest populations through this sort of trapping. Some chemicals are very potent attractants and can lure pests from long distances. The pheromones are an important group of such chemicals. Pheromones are produced by insects and other animals to communicate with other members of the same species. Minute amounts of the chemical are produced by each individual and other members of the same species can detect and respond to the presence of the pheromone in the air, water, or on the soil. The sex attractants are the most important group of pheromones in insect pest management; in nature they attract members of the opposite sex for mating.



Pheromones of many insects have been identified, synthesized, and are available commercially. At the present time, pheromones are primarily used in monitoring pest populations rather than in direct control techniques. Traps are baited with pheromones and, when the pests are detected in the traps, pesticide applications are made. This technique has made it possible to reduce the number of applications and amount of pesticides used to manage several important insect pests.

Repellents have been used to repel pests for many years. In general they are useful against insects and other arthropods which attack people and livestock.

GENETIC CONTROL

In a few spectacular cases, massive populations of pest species have been managed and even locally eradicated through the use of genetic techniques. The most well-known example of this kind of pest control involved the eradication of the screw-worm fly in the southeastern U.S. The screw-worm fly lays its eggs in open wounds on cattle and other animals. The larvae burrow into the healthy flesh of the animal and, if untreated, may kill the host animal. This fly caused millions of dollars of damage to cattle and other livestock throughout the southern portion of the U.S. Entomologists reared, sterilized, and released millions of screw-worm flies. After release, the flies mated with the normal wild flies and, because the released flies were sterile, they were unable to produce offspring. Within a few months the screw-worm fly population in the southeastern U.S. had completely died out. A similar technique has recently been employed to eradicate the Mediterranean fruit fly in southern California. Since successful application of this technique requires extensive technical knowledge and production facilities, it is only utilized on a large scale by major agencies.

GLOSSARY

Many of the words defined here have additional meanings. The definitions given here are related to pests, pesticides, and pest control.

A

Abrasion	The process of wearing away by rubbing or grinding. Also, a scrape, scratch, or sore that breaks the skin.
Abrasive	Something that grinds down or wears away an object. Example: wettable powders are abrasive to pumps and nozzles.
Abscission	The separation of fruit, leaves, or stems from a plant.
Absorb	To soak up or "drink in," as when a pesticide or other material is taken into a plant, animal, or the soil.
Absorption	Movement of a chemical into a plant, animal, or the soil. Plants absorb through leaves, stems, or roots, while animals absorb through skin. breathing organs, stomach, mouth, or intestines. Compare to *adsorption.*
Absorptive clay	A special type of clay powder which can soak up chemicals and hold them. It is sometimes used to clean up spills of pesticides.
Acaricide	A pesticide used to control mites and ticks. Same as *miticide.*
Accumulate	To build up, add to, store, pile up.
Accumulative pesticides	Those chemicals which tend to build up in animals or the environment.
Acre	43,560 square feet; equal to an area of land 440 feet long by 99 feet wide; approximately equal to a square area of land that is 209 by 209 feet; or a rectangle that is 436 by 100 feet.
Activator	A material added to a pesticide to increase its toxicity.
Active ingredient	The substance in a pesticide product which kills or controls pests or prevents damage by them. (Note: This is the actual poison in a product.)
Actual dosage	The amount of active ingredient (not formulated product) which is applied to an area or other target.
Acute dermal toxicity	How poisonous a single dose (or exposure) of a pesticide is when absorbed through the skin.
Acute inhalation toxicity	How poisonous a single dose (or exposure) of a pesticide is when breathed into the lungs.

Acute oral toxicity	How poisonous a single dose (or exposure) of a pesticide is when taken by mouth (eaten, swallowed, licked, etc.).
Acute poisoning	Poisoning which occurs after a single dose (or exposure) of a pesticide.
Acute toxicity	How poisonous a pesticide is to an animal or person after a single dose (or exposure).
Additive	Any substance added to a pesticide to improve its performance. Same as *adjuvant*.
Adherence	When a substance sticks (adheres) to a surface.
Adhesive	An adjuvant which helps a pesticide stick to a treated surface.
Adjuvant	Any substance (inert ingredient) added to a pesticide formulation to make the formulation work better. Examples: adhesive, emulsifier, penetrant, spreader, wetting agent. Same as *additive*.
Adsorption	The process by which a substance is held (bound) to the surface of a soil particle or mineral in such a way that the substance is only available slowly. Clay and highly organic soils have a tendency to adsorb pesticides. Compare to *absorption*.
Adult	A full-grown, sexually mature insect, mite, nematode, or other animal. The adult stage is often related to dispersal and the beginning of new colonies or infestations.
Adulterated	Any pesticide whose quality, strength, or purity falls below the standard stated on its label. Also, a food, feed, or product which contains illegal pesticide residues.
Aerobic	Living in air. The opposite of *anaerobic*.
Aerosol (generator)	Low concentrate solution of a pesticide or combination of pesticides, usually in an oil solution formulated especially for use in generators.
Aerosol (pressurized can)	A small amount of pesticide or a combination of pesticides that is driven through a fine opening by an inactive gas under pressure when the nozzle is triggered, producing an extremely fine spray, mist, or fog of very tiny solid or liquid particles (droplets) suspended in the air.
Agitate	To keep a pesticide formulation mixed up; to keep the formulation from separating out or settling in the tank.
Agitation	The process of mixing or stirring in a tank.
Agitator	The paddle (or other mechanical device), air, or hydraulic action used to keep a pesticide formulation mixed in the tank.
Agricultural commodity	Any plant or part of a plant, animal, or animal product that is to be bought or sold.
Air blast sprayer	A machine which can deliver high and low volumes of spray; used for orchards, shade trees, vegetables, and fly control.
Algicide	A pesticide used to control algae, especially in stored water or industrial water.
Alkaloids	Chemicals present in some plants; some are used as pesticides.
Anaerobic	Living where there is no air (or free oxygen). The opposite of *aerobic*.
Animal sign	Evidence of an animal's presence in an area.
Annual	A plant that grows from a seed, produces flowers, fruit or seed the same year, and then dies.
Antagonism	The loss of activity (or decrease in effectiveness) which is a result of two or more chemicals being exposed to each other or mixed together.
Antibiotic	A substance which is used to control pest microorganisms.
Anticoagulant	A pesticide which prevents the normal clotting of blood.

Antidote	A practical immediate treatment in the case of poisoning, including first aid. A remedy (or treatment) given by a doctor to counteract (or reduce) the effects of pesticide poisoning. (***Note: If poisoning occurs, get medical help!***)
Anti-siphoning device	A small piece of equipment attached to the filling hose to prevent fill water from draining back into the water source. Example: check valve.
Antitranspirant	A pesticide which reduces water loss (prevents drying out) by coating the leaves of a plant.
Aphicide	A pesticide used to control aphids or plant lice.
Apiary	A place where colonies of bees are intentionally kept for the benefit of their honey-producing and pollinating activities.
Application	Putting (or directing) a pesticide on or in plants, animals, buildings, soil, air, water or other site (target).
Applicator	A person or piece of equipment which applies pesticides.
Apply uniformly	To spread, put, place or distribute a pesticide evenly.
Aquatic plants or weeds	Plants or weeds that grow in water. The plants may float on the surface, grow up from the bottom of the body of water (emergent), or grow under the surface of the water (submergent).
Aqueous	Indicates that water is present, especially in a solution (as in "an aqueous solution").
ARS	Agricultural Research Service of the U.S. Department of Agriculture.
Arsenicals	Pesticides which contain arsenic.
Artificial respiration	A form of first aid given to a person who has stopped breathing in order to get the person breathing again.
Aseptic	Free of disease-causing organisms.
Atomize	To break up a liquid into very fine droplets by forcing it through a nozzle-like device with a very small opening.
Atropine sulfate or atropine	An antidote used by doctors to treat people or animals poisoned by organic phosphate and carbamate pesticides in an attempt to save their lives.
Attractants	Substances or devices capable of attracting insects or other pests to areas where they can be trapped or killed.
Attractive nuisance	A legal term for any object which might attract children or other persons to it and then might injure or hurt them as a result. Examples: sprayers, empty pesticide containers, a bottle or food container filled with pesticide.
Avicide	A pesticide used to control birds.
Avoid prolonged contact	Do not get exposed to or breathe in the vapor (gas) of a pesticide for very long.

B

Bacteria	One-celled microorganisms (germs), some of which cause diseases in plants or animals. They cannot be seen without a microscope. (Singular: bacterium)
Bactericide	A pesticide used to control bacteria.
Bait	A food or other material which will attract a pest to a pesticide or to a trap where it will be trapped or killed.
Bait shyness	The tendency for rodents, birds, or other pests to avoid a poisoned bait.
Band	Application to a strip (band) over or along each row.
Beneficial	Useful or helpful to people (as in "a beneficial insect"). Example: an insect which feeds on plant-damaging insects.

Biennial — A plant with a two-year life cycle. It produces leaves and stores food in the first year; it produces fruits and seeds in the second year, and then dies.

Bioconcentration — The process of a pesticide becoming concentrated in plants or animals.

Biological control — Controlling pests by using predators, parasites, and disease-producing organisms instead of using pesticides.

Biomagnification — Same as *Bioconcentration.*

Bipyridyliums — A group of synthetic organic pesticides which includes the herbicide paraquat.

Bird repellent — A pesticide which repels birds or discourages them from roosting or feeding. Compare to *Avicide.*

Boom — A section of pipe (or tubing) which connects several nozzles so that a pesticide can be applied over a wider area.

Botanicals — Pesticides made from plants. Examples: nicotine, pyrethrum, rotenone, and strychnine. (Note "Pyrethroids" are synthetic pyrethrum.) Same as *Plant-derived pesticides.*

Brand name — The manufacturer's name for the product.

Broadcast application — A uniform application over an entire area.

Broadleaf plants or species or weeds — Those plants having wide, rounded, or flattened leaves and netted veins. Examples: dandelions and roses. Compare to *Narrowleaf plants.*

Broad spectrum pesticide — A pesticide that controls or is toxic to a wide range of pests when applied correctly; it is used when several different pests are a problem. Same as *Non-selective.*

Brush control — The control of woody plants.

Buildup — Accumulation of a pesticide in soil, animals, or in the food chain.

C

Calibrate — To measure or figure out how much pesticide will be applied by the equipment to the target in a given amount of time.

Calibrated — Measured; checked. Knowing the amount of pesticide being applied by each nozzle or opening of a sprayer, duster, or granular applicator to a given area, plant, or animal in a given amount of time.

Calibration — Measurement of the delivery rate of application equipment.

Cancelled — A pesticide use that is no longer registered as a legal use by the EPA; remaining stocks can only be used by order of the Administrator, EPA. (Note: This order is less severe than *Suspended.*)

Canister — A metal or plastic container filled with absorbent materials which filter fumes and vapors from the air before they are breathed in by an applicator.

Carbamate — A synthetic organic pesticide which contains carbon, hydrogen, nitrogen, and sulfur, belongs to a group of chemicals which are salts or esters of carbonic acid. Carbamates may be fungicides, herbicides, or insecticides. Examples: aldicarb, carbaryl, carbofuran, and methomyl.

Carcinogen — A substance or agent capable of producing cancer.

Carcinogenic — A term which describes the cancer-producing property of a substance or agent; capable of causing cancer.

Carrier — An adjuvant which is added to (or which dilutes) the active ingredient so that the formulation becomes easier to apply. Examples: petroleum solvents, talc. Also, the material which carries the pesticide to the target. Examples: water in a hydraulic sprayer, air in a mist blower.

Cartridge	The part of the respirator which absorbs fumes and vapors from the air before the applicator breathes them in.
Causal organism	The organism that produces a specific disease. See *Pathogen.*
"Caution"	A signal word used on pesticide labels that lets the user know the pesticide is slightly toxic (Toxicity Categories III and IV), as defined by FIFRA (Amended).
CDFA	California Department of Food and Agriculture.
Certification	The recognition by a certifying agency that a person is competent and thus authorized to use or supervise the use of restricted use pesticides.
Certified applicator	An individual who is certified to use or supervise the use or supervise the use of any restricted use pesticides covered by her/his certification.
Chemically inactive	Will not easily react with any other chemical or object. Examples: clay talc. See *Inert ingredient.*
Chemical name	The scientific name telling the contents or formula of the active ingredients of the pesticide.
Chemosterilant	A chemical that can prevent reproduction (causes sterility) in insects.
Chlorates	Substances which can be herbicides and defoliants; they act as contact poisons, are translocated, and may be absorbed from the soil to kill both plant roots and tops. Chlorates cause chlorosis of leaves and a starch depletion in stems and roots when applied in less than lethal doses.
Chlorinated	A synthetic organic pesticide that contains chlorine, carbon, and hydrogen; they are generally very persistent (compared to carbamates or organophosphates). Examples: DDT, endrin, lindane. Same as *Organochlorine.*
Chlorosis	The yellowing of a plant's normally green tissue because of a partial failure of the chlorophyll to develop.
Cholinesterase	A body enzyme (chemical catalyst) found in animals and people that helps regulate the activity of nerve impulses and is necessary for proper nerve function. It is destroyed or damaged when organic phosphates or carbamates enter the body by any path or in any fashion.
Cholinesterase inhibitor	Any carbamate, organophosphate, or other pesticide that can interrupt the action of enzymes.
Chronic poisoning	Poisoning which occurs as a result of repeated exposures (or doses of) pesticides over a period of time.
Chronic toxicity	How poisonous a pesticide is to an animal or person after small, repeated doses (exposures) over a period of time.
Classification	The process of assigning pesticides into groups according to common characteristics; classification may be by target species, by chemical nature, by manner of formulation, by mode of action, and by toxicity. Also, the process of assigning organisms into groups according to common characteristics; classification may be by target species, by chemical nature, by manner of formulation, by mode of action, and by toxicity. Also, the process of assigning organisms into groups accoring to common characteristics.
Common exposure route	A likely way (oral, dermal, respiratory) that a pesticide may reach and/or enter an organism.
Common name	A well-known, simple name of a pesticide accepted by the Pesticide Regulation Division of the EPA.
Compatibility	The mixture of two or more pesticides without their effectiveness being reduced or altered; when chemicals "get along" with each other.
Compatible	Two or more pesticides (or chemical compounds) are compatible if they can be mixed without affecting each other's properties.

Complete metamorphosis — The process of insect development which includes the egg, larva, pupa, and adult stages.

Compressed air sprayer — A sprayer which usually has a 1 to 3 gallon capacity with an extension rod, an air pump to develop pressure, and often includes a shoulder strap for carrying; it is not suitable for spraying at heights over 6 to 8 feet.

Concentrate — A pesticide formulation (liquid or dry) as it is sold before diluting; usually contains a high percentage of active ingredient to save shipping and storage charges and yet be of convenient strength and composition for dilution. Also, the opposite of *Dilute*.

Concentration — The amount of active ingredient contained in a given volume or weight. Example: 4 pounds per gallon. Also, the percentage of the active ingredient. Example: a 50% wettable powder.

Condemnation — The removal of a crop or product which does not meet the legal standards for tolerances on foods and therefore is not to be sold.

Contact herbicide — A pesticide that kills primarily by contact with plant tissue rather than as a result of translocation. Only that portion of a plant contacted is directly affected.

Contact poison — A pesticide which kills when it touches or is touched by a pest.

Contaminate — To add an unwanted material, such as a pesticide, which may do harm or damage; to pollute, make impure, or make unfit for use.

Corrosion — The process of wearing away by chemical means.

Corrosive poison — A type of poison that contains a strong acid or base which will severely burn the skin, mouth, stomach, etc.

Coverage — The degree of uniformity of pesticide application over a surface.

Crop — A plant growing where it is desired.

Crop tolerance — The ability of a crop to be treated with a pesticide but not be injured; the degree of pesticide treatment a crop can withstand without injury.

Cross contamination — When one pesticide gets into or mixes with another pesticide accidentally; usually occurs in a pesticide container or in a poorly cleaned sprayer.

Cross-resistant — When a pest population which has become resistant to one pesticide also becomes resistant to other chemically related pesticides.

Crucifers — Plants belonging to the mustard family. Examples: mustard, cabbage, radish, and turnip.

Cucurbits — Plants belonging to the gourd family. Examples: cucumber, pumpkin, and squash.

Cumulative effect — The result of some poisons which build up or are stored in the body so that small amounts eaten or contacted over a period of time can sicken or kill an animal or person. Examples: anticoagulant, rodenticides, mercury compounds, thallium sulfate.

Customary — A system of measurement used in the United States. The units of the customary system are feet and yards (for length), ounces and pounds (for weight), and various kinds of units for volume (cups, pints, quarts, gallons, etc.).

D

"Danger" — A signal word used on pesticide labels that lets the user know the pesticide is highly toxic (Toxicity Category I), as defined by FIFRA (Amended). This signal word is always accompanied by the word "Poison" and the skull and crossbones symbol.

Days to harvest — The minimum number of days, established by law, between the final pesticide application and the harvest date.

Days to slaughter — The minimum number of days, established by law, between the final pesticide application and the date the animal is slaughtered.

Deciduous plants — Perennial plants that lose their leaves during the winter.

Decontaminate — To make safe, purify, make fit for use again by removing any pesticide from equipment or other surfaces as directed by a pesticide label, an agricultural authority, or the manufacturer of the pesticide.

Deflocculating agent — An adjuvant which prevents precipitation (settling out) of solids in the suspension in the spray tank.

Defoliant — A pesticide which causes the leaves of a plant to drop off.

Defoliate — To strip of leaves; to apply a defoliant.

Degradability — A chemical's ability to break down into less complex compounds or elements.

Degradation — The breakdown of a more complex chemical into a less complex form; this process can be a result of the action of microbes, water, air, sunlight, or other agents.

Degrade — Decompose; break down.

Delayed action — The lack of an immediate response by a plant to an application of an herbicide. With some herbicides a delayed response is expected and it may take a while for maximum effects to be observed. Usually treated plants stop developing soon after treatment and then gradually die.

Deposit — The amount of pesticide remaining on the target immediately following an application. Compare to *Residue*.

Dermal — Through or by the skin; of or pertaining to the skin.

Dermal toxicity — How poisonous a pesticide is to an animal or person when in contact with and absorbed through the skin. (Note: Dermal toxicity is the greatest hazard to people handling pesticides. Dermal exposure often occurs because a pesticide is spilled onto clothing and protective equipment or directly onto the skin. Be careful!)

Desiccant — A pesticide used to draw moisture from or dry up a plant, plant part, or insect. Desiccants are used primarily for pre-harvest drying of actively growing plant tissues when seed or other plant parts are developed but only partially mature; or for drying of plants which normally do not shed their leaves, such as rice, corn, small grains, and cereals.

Desiccation — Dehydration (removal of tissue moisture) by chemical or physical action. Drying chemicals which promote desiccation are called *desiccants*.

Detoxify — To make harmless; to take out, take away, or neutralize a poison; to remove a poisonous effect.

DFA — Department of Food and Agriculture.

Diluent — Any liquid or solid material used to weaken ("water down") or carry an active ingredient (concentrated pesticide).

Dilute — To make a pesticide thinner or weaker by adding water, oil, or other liquid or solid; to "water down". Also, the opposite of *Concentrate*.

Dip — The complete or partial immersion (dunking) of a plant, animal or object in a pesticide.

Directed application — Aiming a pesticide at a specific area such as at a portion of a plant, animal, or structure or at a row or bed.

Dispersing agent — An adjuvant that reduces the attraction between particles.

Disposal — The act or process of discarding or throwing away a pesticide or pesticide container; can include burning, rinsing, re-use, deposit-return, or recycling. (Note: Disposal should be done safely and carefully, as directed by the pesticide label, an agricultural authority, or the manufacturer of the pesticide.)

Dormant	A state in which seeds or other plant organs temporarily stop growing.
Dormant spray	A pesticide application made before trees and other plant life begin to leaf out in the spring.
Dose (dosage)	Amount, quantity, or portion of a pesticide which is applied to a target. Also, a consistent measure used in testing to determine acute and chronic toxicities.
Downwind	Direction toward which the prevailing wind is blowing.
Drench	Saturation (thorough soaking) of the soil with a pesticide or an oral treatment of an animal.
Drift	The movement of pesticide droplets or particles by wind and air currents from the target area to an area not intended to be treated.
Dust (D)	A finely ground dry mixture combining a small amount of pesticide with an inert carrier such as clay, talc, or volcanic ash.

E

Ecology	The study of the relationship between a plant or animal and its surroundings.
Economic poison	The term formerly used for *Pesticide*.
Emergence	The act of appearing, as when a young plant breaks through the surface of the soil or when an insect comes out of an egg or pupa.
Emulsifiable concentrate solution (EC or E)	A solution which contains a high concentration or large amount of active ingredient which should be mixed with water; may contain two or more pounds of active ingredient per gallon of concentrate.
Emulsifier (emulsifying agent)	A chemical which helps one liquid form tiny droplets and thus remain suspended (mixed up) in another liquid.
Emulsion	A mixture in which one liquid is suspended (mixed up) as tiny droplets in another liquid. Example: oil in water.
Encapsulation	A method of formulating pesticides, in which the active ingredient is encased in a material (often plastic), resulting in sustained pesticidal release and decreased hazard. Also, a method of disposal of pesticides and pesticide containers by sealing them in sturdy, waterproof, chemical-proof containers which are then sealed in thick plastic, steel, or concrete to resist damage of breakage so the contents cannot get out.
Environment	Your surroundings, including water, air, soil, plants, and animals.
Environmental Protection Agency	The federal agency responsible for the protection of the environment in the United States.
EPA	Environmental Protection Agency of the United States.
Eradicant	A pesticide which kills the pest after it appears.
Eradicant fungicide	A pesticide which kills a fungus after it appears on or in a plant.
Evaporate	To form a gas and disappear into the air; to vaporize.
Evaporation	The process of a solid or liquid turning into a gas.
Exemption	An exception to a policy, rule, regulation, law, or standard.
Exoskeleton	The segmented external skeleton of an insect; the insect's "skin".
Exposure	When contact occurs with a pesticide through skin (dermal), mouth (oral), lungs (inhalation/respiratory), or eyes.

F

Face shield — A transparent piece of protective equipment used by a pesticide applicator to protect the face from exposure.

FDA — Food and Drug Administration (of the United States).

Federal Insecticide, Fungicide, and Rodenticide Act (amended) — The federal law pertaining to pesticide regulations and use in the United States. Often includes the word "(Amended)" because the original act was changed. Commonly referred to as "FIFRA (Amended)".

FIFRA (amended) — Federal Insecticide, Fungicide, and Rodenticide Act (Amended).

Finite tolerance — The maximum amount of pesticide which can legally remain on a food or feed crop at harvest after the pesticide has been directly applied to the crop.

First aid — The first effort to help a victim while medical help in on the way.

Flowable (F) — Very finely ground solid material which is suspended in a liquid; usually contains a high concentration or large amount of the active ingredient and must be mixed with water when applied.

Foaming agent — A material which causes the pesticide mixture to form a thick foam. It is used to reduce drift.

Fogger — An aerosol generator; a piece of pesticide equipment that breaks some pesticides into very fine droplets (aerosols or smokes) and blows or drifts the "fog" onto the target area.

Foliage — The leaves, needles, stems, and blades of plants and grasses.

Foliar application — Spraying a pesticide onto the stems, leaves, needles, and blades of grasses, plants, shrubs, or trees.

Food chain — A phrase that describes how all living organisms are linked together and depend on each other for food.

Formulation — The pesticide product; it may contain one or more active ingredients, the carrier (if needed), and other additives (if needed) to make it ready for sale in a form that is safe and easy to store, dilute, and apply.

Fume — A smoke, vapor, or gas.

Fumigant — A pesticide which enters the pest in the form of a gas and kills it. The fumigant may be a liquid which becomes a gas when it is applied. Examples: methyl bromide, phostoxin, chloropicrin, and carbon bisulfide.

Fumigation — The use of a fumigant to kill a pest.

Fungi — Groups of small plant organisms (often microscopic) which cause rots, molds, and plant diseases; they lack cholorophyll (green coloring). Fungi grow from seed-like spores and produce tiny thread-like growths. Some fungi can attack and destroy non-living things. Examples: molds, mushrooms, and yeasts. (Singular: fungus).

Fungicide — A pesticide used to control fungi.

Fungistat — A pesticide that keeps fungi from growing or slows down the growth.

Fungus — Singular of *Fungi*.

G

Gas mask — A type of respirator which covers the entire face and protects the eyes as well as the nose and mouth. It filters and cleans the air better than cartridge respirators and is less likely to leak around the edges. This device is effective against air which contains sprays, dusts, or gases. (Note: A simple respirator will protect against a spray or dust without covering the eyes, but not against poisonous gases.)

GPA (G.P.A.)	Gallons per acre.
GPM (G.P.M.)	Gallons per minute.
Gram	A metric weight measurement equal to 1/1000th of a kilogram; approximately 28.5 grams equal one ounce.
Granular pesticide	An active ingredient mixed with or coating small pellets or sand-like material, which is often used to control soil pests.
Granule (G)	A pesticide in the form of pellets, all of which are larger than dust particles. A granular formulation is dry and ready-to-use, and is made of small amount of pesticide and an inert carrier; the active ingredient is mixed with, absorbed, adsorbed, or pressed on or into the inert carrier. Same as *Granular pesticide.*
Growth regulator	A pesticide which increases, decreases, or in some way changes the normal growth or reproduction of a plant (or insect). Example: growth inhibitor.
Growth stages of cereal crops	Tillering: when additional shoots are developing from the flower buds. Jointing: when stem internodes begin elongating rapidly. Booting: when upper leaf sheath swells due to the growth of developing spike or panicle. Heading: when seed head is emerging from the upper leaf sheath.

H

Hand sprayer	A small, portable, pesticide sprayer that can be carried and operated.
Hard (water)	Water containing soluble salts of calcium and magnesium, and sometimes iron.
Harvest aid	A pesticide used to remove the leaves from cotton plants, kill potato vines, and in any other way make it easier to machine harvest a crop. See *Defoliant, Desiccant.*
Harvest date	The day a crop is removed from its site of growth, as from a tree, bush, or vine, or cut (as in the case of alfalfa). (Note: "removed from" does not refer to when a crop is removed from the field, but rather to when the crop is picked, cut, dug up, etc.)
Hazard	The chance that injury or harm will come to the applicator, other persons, plants, or animals because of pesticide use; the risk of danger resulting from a combination of toxicity and exposure.
Hectare	A metric area measurement equal to 10,000 square meters or approximately 2.47 acres; one hectare is equal to 100 acres.
Herbaceous plant	A plant that does not develop woody tissue.
Herbicide	A pesticide used to control unwanted plants.
High pressure sprayer.	Same as *Hydraulic sprayer.*
High volume spray	A spray application of more than 60 gallons per acre.
Hormones	This term commonly refers to synthetic (man-made) chemicals that affect or regulate growth activity of plants or animals. Also, chemicals naturally present in plants or animals that control growth or other physiological processes.
Host	The living plant or animal that a pest depends on for survival.
Hydraulic agitator	A device which keeps the pesticide formulation in the tank from settling out (precipitating) by means of water flow under pressure.
Hydraulic sprayer	A machine which delivers large volumes of pesticide spray at high pressures (up to several hundred pounds per square inch) to the target; used for fruit trees, shade trees, and ornamentals. Same as *High pressure sprayer.*

Hydrocarbon — A chemical whose molecules contain only carbon and hydrogen atoms. Crude oil is a mixture largely of hydrocarbons. Methane (natural gas) is the simplest hydrocarbon, with each molecule containing one atom of carbon and four atoms of hydrogen.

Hydrogen ion concentration — A measure of acidity or alkalinity, expressed in terms of the pH of the solution. See *pH.*

I

IGR — Insect growth regulator.

Illegal residue — A residue tht is in excess of a pre-established and government-enforced safe level.

Immune — A state of not being affected by a disease or poison; exempt from or protected against.

Impermeable — Cannot be penetrated by gases or liquids. "Semipermeable" means that some substances can penetrate (pass through) and others cannot.

Inactive — Not involved in the pesticide action; not reacting chemically with anything.

Incinerator — A special high-heat furnace or burner which reduces everything to nontoxic ashes and vapors; used for disposing of some highly toxic and moderately-to-slightly toxic pesticides.

Incompatible — When two or more pesticides are mixed and the effectiveness of one or more is decreased; therefore, not capable of being mixed or used together. Also, when two or more pesticides are mixed and application causes unintended injury to plants or animals.

Incorporate into soil — To mix a pesticide into the soil by mechanical means. Same as *Soil incorporation.*

Induce vomiting — To make a person or animal throw up.

Inert ingredient — The substance (or substances) in a pesticide product which has no pesticidal (controlling or killing) action; an inactive ingredient. Compare to *Active ingredient.*

Infestation — Pests that are found in an area or location where they are not wanted.

In-furrow — An application to or in a furrow in which a crop is planted.

Ingest — To eat, swallow, drink, or in some other way take into the digestive system.

Inhalation — The process of taking air into the lungs; breathing in.

Inhalation toxicity — How poisonous a pesticide is to an animal or person when breathed in through the lungs.

Inhibitor — A pesticide used to prevent or suppress growth or other physiological processes in plants. Sometimes referred to as a "growth inhibitor". See *Growth regulator.*

Inject — To force a pesticide into a plant, animal, building, other structure, or the soil.

Inorganic pesticides — Pesticides which do not contain carbon. Examples: Bordeaux mixture, copper sulfate, sodium arsenite, sulfuric acid, and salt.

Insect — A small invertebrate animal with three body regions and six jointed legs; may have two, four, or no wings.

Insect growth regulator — A synthetic organic pesticide which mimics insect hormonal action so that the exposed insect cannot complete its normal development cycle, and dies without becoming an adult.

Insecticide — A pesticide used to control insects.

Instar — The form of an insect between molts.

Integrated control The use of more than one approach to or method of pest control, including cultural practices, natural enemies, and selective pesticides. (Note: If a pesticide is needed, it should do the least possible damage to the pest's natural enemies.)

Interval The time between two pesticide applications. Also, the time period between the final pesticide application and harvest.

Invertebrate Any animal without a bony spinal column. Examples: insects, molllusks.

Invert emulsifier An adjuvant which allows water to remain suspended in oil rather than settling out (precipitating); it is the reverse of the usual emulsifier which allows suspension of oil in water.

J

Jointly liable When two or more persons or companies share legal responsibility for *Negligence.*

K

KG Kilogram.

Kilogram A metric weight measurement equal to 1000 grams or approximately 2.2 pounds.

L

Label Technical information about the pesticide in the form of printed material attached to or printed on the pesticide container.

Labeling Technical information about the pesticide in the form of printed material provided by the manufacturer or its agent, including the label, flyers, handouts, leaflets, and brochures.

Lactation The period during which an animal produces and secretes milk.

Larva A young growing insect in the stage after hatching from the egg and before becoming a pupa. In this early form, the immature insect is worm-like or grub-like and usually does not look like an adult. Many insects, like the caterpillar, cause most or all of their damage as larvae (plural of larva).

Larvacide A pesticide used to kill the larvae of insects.

LC_{50} The concentration of an active ingredient in the air which, when breathed in through the lungs, kills half of the test animals exposed to it; an expression of a compound's toxicity when present in the air as a gas, vapor, dust, or mist. LC-50 is generally expressed in ppm (parts per million) when a gas or vapor, and in micrograms per liter when a dust or mist. It is often used as the measure of *Acute inhalation toxicity.* (Note: The lower the LC-50 number value, the more poisonous the pesticide.)

LD_{50} The dose or amount of an active ingredient which, when taken by mouth or absorbed by the skin, kills half of the test animals; an expression of a compound's toxicity. LD-50 is generally expressed in mg/kg (milligrams per kilogram). It is commonly used to measure *Acute oral toxicity* or *Acute dermal toxicity.* (Note: The lower the LD-50 number value, the more poisonous the pesticide.)

Leaching The movement of a substance downward or out of the soil as the result of water movement.

Legal residue A residue that is within a safe level according to the regulations.

Lethal Causing or capable of causing death; deadly; fatal.

Liable (liability) Legally responsible for; something that someone is legally responsible for.

Life cycle The procession of stages in the life development of an organism.

Liter A metric volume measurement equal to one cubic decimeter or, when dealing with liquid measurement, a little more than one quart.

Low concentrate Solution (S) A solution which contains a low concentration or small amount of active ingredient in a highly refined oil. (Note: These solutions are usually purchased as stock sprays and space sprays and for use in aerosol generators.)

Low pressure boom sprayer A machine which can deliver low to moderate volumes of pesticide at pressures of 30-60 psi; most often used for field and forage crops, pastures, and rights-of-way. Compare to *Hydraulic sprayer.*

Low-volatile A liquid or solid that does not evaporate quickly in the normal range of temperatures and pressures.

Low volume air sprayer A machine similar to an *Air blast sprayer,* but with somewhat lower water volume and higher air velocity, which produces extremely fine droplets. Same as *Mist blower.*

Low volume spray A spray application of 5 to 20 gallons per acre.

M

Mammals Warm-blooded animals that nourish their young with milk; their skin is more or less covered with hair.

Marine Of the ocean or sea; having to do with plants and animals which live in, on, or around an ocean or sea.

Materials A substance; often used to mean a pesticide, pesticide formulation, pesticide chemical, active ingredient, or additive ingredient.

Maximum dosage The largest amount of a pesticide that can be used safely, without excess residues or damage occurring to whatever is being treated.

Mechanical agitation The stirring, paddling, or swirling action of a device which keeps a pesti- and any additives thoroughly mixed in the spray tank.

MESA Mining Enforcement and Safety Administration. All respirators designated for use with pesticides are jointly approved by MESA and NIOSH. See NIOSH.

Metabolite A compound which results from chemical action on a pesticide inside a living organism. The metabolite may be more toxic or less toxic than its "parent" pesticide. Metabolites may in some cases develop when a pesticide is exposed outside a living organism.

Metamorphosis A change in the shape, form (or structure), and size of an insect.

Metric A system of measurement used by most of the world. Because of its international use and scientific application, the U.S. has stated its intention to gradually adopt the metric system. The units of the metric system are meters (for length), grams (for weight), and liters (for volume).

MG Milligram.

MG/KG Milligrams per kilogram; used to express the amount of pesticide – in mg/kg of animal body weight – which produces a known effect; a ratio of weight of pesticide per weight of animal. 1,000,000 mg = 1 kg = approximately 2.2 pounds.

Microbal pesticide A pesticide whose "active ingredient" is a bacteria, virus, or other tiny plants or animals. Examples: *Bacillus thuringiensis* (a bacteria) and nuclear polyhedrosis virus.

Microgram A metric weight measurement equal to 1/1,000,000th of a gram; approximately 28,500,000 micrograms equal one ounce.

Milligram — A metric weight measurement equal to 1/1000th of a gram; approximately 28,500 mg equal one ounce.

Miscible liquids — Two or more liquids that can be mixed and will remain mixed under normal conditions.

Misdiagnose — To make a mistake in deciding what pest has caused the problem.

Mist blower — Same as *Low volume air sprayer.*

Mites (spiders and ticks) — Tiny animals closely related to insects; they have eight jointed legs, two body regions, no antennae (feelers), and no wings. A mite has six legs during the nymphal stage. Mites are often grouped with ticks and spiders.

Miticide — A pesticide used to control mites and ticks; same as *Acaricide.*

Mode of action — The manner in which an herbicide controls weeds or plant growth. Also, the ways in which pesticides affect people and other mammals.

Mold — A fungus-caused growth often found in damp or decaying areas or on living things.

Mollusks — Any of a large family of invertebrate animals, including snails and slugs.

Molluscicide — A pesticide used to control slugs and snails.

Monitoring system — A regular system of keeping track of and checking up on whether or not pesticides are escaping into the environment.

MPH — Miles per hour.

Multipurpose — Capable of doing more than one job; a multipurpose pesticide can be used to control more than one pest.

Mutagenic — Capable of producing a genetic change.

Mycoplasma-like organisms — Organisms recently discovered to be the cause of many plant diseases formerly attributed to viruses; organisms smaller than bacteria and larger than viruses.

N

Narrowleaf plants or species or weeds — Those plants having narrow leaves and parallel veins. Examples: grasses, sedges, rushes, and onions. Compare to *Broadleaf plants.*

Natural enemies — The predators and parasites in the environment which attack pest species.

Necrosis — Death in a particular part of a living tissue. Example: the death of a certain area of a leaf.

Necrotic — Showing varying degrees of dead spots or areas.

Negligence — Failure to do a job or duty; an act or state of neglectfulness.

Negligible residue — A tolerance which is set on a food or feed crop which contains a very small amount of pesticide at harvest as a result of indirect contact with the chemical.

nematicide — A pesticide used to control nematodes; often applied as a soil fumigant to control nematodes infesting roots of crop plants.

Nematode — A worm-like organism which feeds on or in plants and animals. Nematodes have many common names, including roundworms, threadworms, and eelworms. Some are microscopic; some are larger; many kinds are internal parasites of people and other animals.

Neoprene — A synthetic rubber often used to make gloves and boots which offer protection against most pesticides. (Note: There are times when neoprene gloves and boots are not recommended. Generally, however, neoprene is a very good material for protective equipment when handling pesticides.)

Nervous system — All nerve cells and tissues in animals, including the brain, spinal cord, ganglia, nerves, and nerve centers.

NIOSH — National Institute for Occupational Safety and Health. All respirators designated for use with pesticides are jointly approved by NIOSH and MESA. See *MESA*.

Nitrophenol — A synthetic organic pesticide which contains carbon, hydrogen, nitrogen, and oxygen.

Non-accumulative — Does not build up or store in an organism or in the environment. See *Accumulative pesticides*.

Non-corrosive poison — Opposite of *Corrosive poison*.

Non-persistent pesticide — A pesticide that breaks down almost immediately, or only lasts for a few weeks or less, and turns into non-toxic by-products. Examples: a pesticide may be broken down by light, moisture, or microorganisms; or it may evaporate.

Non-selective pesticide — A pesticide that is toxic to a wide range of pests, or toxic to more than one animal or plant. Examples: a non-selective insecticide would control more than one kind of insect, but not all plants or other animals; a non-selective herbicide might control all plants in the application site but not all insects, or other animals. Same as *Broad spectrum*.

Non-target — Any plant, animal, or other organism which is not the object of a pesticide application; any species that the pesticide is not aimed at.

Non-toxic — Not poisonous. Opposite of *Toxic*.

Non-volatile — When a substance (usually a liquid) does not evaporate at normal temperatures when exposed to the air. Opposite of *Volatile*.

Noxious weed — A plant considered to be especially unwanted or troublesome.

Nozzles — Devices which control drop size, rate, uniformity, thoroughness, and safety of a pesticide application. The nozzle type determines the ground pattern of coverage. Examples: flat fan, even flat fan, cone, flooding (impact), off-set, atomizing, broadcast, and solid stream nozzles.

Nymph — The stage of development in certain insects after hatching when the young insect looks like an adult insect but lacks fully developed wings.

O

Oils — The liquids used to carry an active ingredient in a pesticide formulation or to weaken a pesticide formulation, or for direct application as a pesticide.

Operating speed — The constant rate at which a pesticide sprayer moves during application; usually measured in miles per hour or feet per minute.

Oral — Of, by, through, or into the mouth.

Oral toxicity — How poisonous a pesticide is to an animal or person when taken by mouth (eaten, swallowed, licked, etc.).

Organic pesticides — Pesticides which contain carbon; the two major groups are petroleum oils and synthetic organic pesticides.

Organism — Any living thing.

Organochlorine — Same as *Chlorinated hydrocarbon*.

Organophosphate — A synthetic organic pesticide which contains carbon, hydrogen, and phosphorous. It acts by inhibiting a blood chemical called *cholinesterase*. As a rule, organophosphates are less persistent than the chlorinated hydrocarbon family. Examples: malathion and parathion.

Original container — The package (bag, can, bottle, etc.) prepared by the manufacturer in which the pesticide is placed and then sold. (Note: The package must have a label telling what the pesticide is, how to use it safely and correctly, and how to safely and legally dispose of the empty container.)

Ornamentals	Plants which are used to beautify homes, gardens, and lawns; included are trees, shrubs, and flowers.
Over-the-top	A pesticide application over the top of a growing plant.
Ovicide	A pesticide used to control eggs, particularly insect, mite, or nematode eggs.

P

2-PAM	An antidote used for organophosphate poisoning, but not for carbamate poisoning. Same as *Protopam chloride*.
Parasite	An organism that lives and feeds on or in another plant or animal (known as the host). The host is usually harmed by the parasite. Parasites are among the worst pests; but when parasites help people by attacking and controlling pests which could injure crops or animals, they become forms of biological control.
Parasitic	Living off of or feeding or on in another organism.
Pathogen	Any disease-producing organism.
Penetrant	An adjuvant which helps a liquid pesticide get into the pores of or get through the outer surface of a leaf or root and into the plant. Also called "penetrating agent".
Penetration	The ability to get through; the process of entering.
Percent by weight	A percentage which expresses the active ingredient weight as a part of the total weight of the formulation. Example: 1 pound of active ingredient added to and mixed with 3 pounds of other materials results in a formulation which is 25% pesticide by weight.
Percent concentration	The weight or volume, expressed as a percentage, of an active ingredient in the final formulation.
Perennial	A plant that normally lives for more than two years. Examples: shrubs and trees.
Persist	To remain or stay.
Persistent	When a pesticide remains in the environment for a fairly long time.
Pest	An unwanted organism; a living thing that competes with people for food and fiber or attacks people directly. According to the law: any form of animal or plant life (including fungi and bacteria) and viruses when they exist under circumstances that make them injurious to plants, people, domestic animals, or other useful vertebrates, useful invertebrates or other articles or substances.
Pesticide	A chemical substance, compound, or other agent used to control, destroy, or prevent damage by or protect something from a pest.
Pesticide chemical	A pesticide which is a chemical rather than a non-chemical pesticide (like a parasite or virus).
Pesticide kill	The death of a large number of non-target organisms due to the careless or improper application or use of a pesticide.
Pesticide tolerance	The amount of pesticide residue which may legally remain on or in a food crop. (Note: The EPA is responsible for establishing federal residue tolerances.)
Petroleum oils	Pesticides used to control insects and plants; they are refined from crude oil.
Petroleum products	Pesticides (and other items) which contain oil, gasoline, kerosene, or similar products.
pH	A measurement scale used to express the acidity or alkalinity of a solution. Examples: a pH of 7, the value for pure distilled water, is regarded as neutral; a pH of 1 to 7 is in the acid range; and a pH of 7 to 14 is in the alkaline range.

Pheromones	Chemicals produced by insects and other animals to communicate with other members of the same species; some are used to monitor insect populations. (Note: Most pheromones used today in pest management are synthetic.)
Phytotoxic	Harmful to plants; poisonous or injurious to plant life.
Piscicide	A pesticide used to control fish.
Plant-derived pesticides	Same as *Botanicals.*
Plant diseases	Harmful conditions or sicknesses which negatively affect plant life; fungi, bacteria, and viruses most often cause plant diseases.
Plant growth regulator	Same as *Growth regulator.*
Point of drip	When a spray is applied until it starts to drip or run off the ends of the leaves and down the stems of plants or off the hair or feathers of animals. See *Runoff.*
Poison	A chemical or material that can cause injury or death when eaten, absorbed, or inhaled by plants or animals, including people.
Poisonous bait (B)	A food or other substance which is mixed with a pesticide so that a pest will be attracted to it, will eat it, and then be killed by it.
Pollinators	Bees, flies, and other insects which visit flowers and carry pollen from flower to flower.
Pollutant	A harmful chemical or waste material discharged into the water, soil, or atmosphere; an agent that makes something dirty or impure.
Pollute	To add an unwanted material (often a pesticide) which may do harm or damage; to contaminate, make unclean or unsafe for use.
Post-emergence	After a specified crop or weed has pushed up through the soil and become visible.
Post-emergent	A pesticide used to control a crop or weed after it has appeared.
Potency	The strength of something. Example: the "potency" of a pesticide means how toxic the pesticide is.
Potentiate	To activate.
Potentiation	The increase in toxicity (usually considered an undesirable effect) of a pesticide when combined with one or more pesticides.
Pour-on	A pesticide which is poured along the midline of the backs of livestock.
PPB	Parts per billion. A way of describing the amount (or concentration) of a chemical in a plant, animal, food, etc.; a ratio which expresses the number of parts of one substance per parts of another substance. One part per billion is equal to 1 pound in 500,000 tons.
PPM	Parts per million. A way of describing the amount (or concentration) of a chemical in a plant, animal, food, etc.; a ratio which expresses the number of parts of one substance per parts of another substance. One part per million is equal to 1 pound in 500 tons.
Predacide	A pesticide used to control vertebrate pests.
Predator	An insect or other animal that attacks, feeds on, and destroys other insects or animals. When predators help people by attacking and control ing pests which could injure crops or animals, they become forms of biological control.
Pre-emergence	Before a specified crop or weed has pushed up through the soil and become visible; the period after planting a seed but before the seedling appears.

Pre-emergent A pesticide used to control a crop or weed before it has appeared.

Pre-harvest The time just prior to the picking, cutting, or digging up of a crop.

Pre-plant The application of a pesticide before planting a crop.

Private applicator A person who has been certified by the Department of Food and Agriculture or the County Commissioner's office to apply, use or supervise the use of any pesticide which is classified for restricted use for purposes of producing any agricultural commodity on property owned or rented by the applicator or the applicator's employer or, if applied without compensation other than trading of personal services between producers of agricultural commodities, on the property of another person.

Product The pesticide as it is packaged and sold; it usually contains an active ingredient plus adjuvants.

Prolonged exposure More than a brief (or one-time) contact with a pesticide or its residue; being in the presence of a pesticide for a long time.

Propellent A liquid in self-pressurized pesticides that forces the active ingredient from the container.

Properties The characteristics (or traits) which describe a pesticide.

Protectant A pesticide that is applied before pests are actually found but where they are expected. Sometimes called a "preventive".

Protective equipment or gear Any clothes, materials, or devices that offer protection from pesticides; especially important when handling or applying highly toxic pesticides. Such equipment can prevent injury or death. Examples: gloves, apron, shoes, coveralls, hat, cartridge, respirator, and gas mask.

Protopam chloride Same as *2-PAM*.

PSI Pounds per square inch. A measurement of pressure.

Pubescent Having hairy leaves or stems.

Pupa The stage between the larva and adult in the development of some insects; an insect in a nonfeeding (usually immobile) stage.

R

Rate The amount of pesticide (or pesticide formulation) which is being delivered to a plant, animal, or area; a measurement of the volume being applied. Rates are expressed in gallons per acre, gallons per minute, gallons per hour, or some other set measure (such as per 1000 square feet); rates are also expressed in pounds per acre or per minute or per hour, etc.

Recommendation A suggestion from or advice given by a Farm Advisor, Extension Specialist, or other agricultural authority.

Re-entry interval The period of time between a pesticide application and when workers can safely go back into an area without wearing protective clothing or equipment. Sometimes called "safe entry time".

Registered pesticide A pesticide which is approved by the U.S. Environmental Protection Agency for use as stated on the label of the container.

Regulated pest A specific organism considered by a state or federal agency to be a pest requiring regulatory restrictions, regulations, or control procedures in order to protect the host, people and/or the environment.

Regulatory officials People who work for the federal or state government and enforce rules, regulations, and laws.

Repeated contact or inhalation An exposure to or a breathing in of a pesticide on several occasions over a period of time.

Repellent A pesticide which makes pests leave or avoid a treated area, surface, animal, or plant.

Residual pesticide — A pesticide remaining in the environment for a fairly long time; the pesticide may continue to be effective for days, weeks, and months.

Residue — The amount of pesticide that remains on or in a crop or animal or on a surface after it has been treated; the quantity of material that remains after a deposit has aged. Residues are usually measured in ppm. Compare to *Deposit.*

Resistant — When an organism is not affected by a pesticide in the manner or to the degree that was expected or that another organism was affected. See *Tolerant.*

Resistant species — A species that is difficult to kill or control with a particular pesticide; one that is able to suppress or retard the damage usually done by a pesticide.

Respiration — Breathing; inhalation.

Respirator — A face mask which filters out poisonous gases and particles from the air, enabling a person to breathe and work safely; it is used to protect the nose, mouth, and lungs from pesticide poisoning. (Note: Be sure to use a respirator, as directed by the label on the pesticide container, when using highly toxic pesticides.)

Respiratory — Having to do with breathing (inhalation); of the lungs, nose, mouth, and oxygen supply to an animal.

Respiratory toxicity — How poisonous a pesticide is to an animal or person when breathed in through the lungs. Also an intake of pesticides through air passages into the lungs.

Restricted material — Same as *Restricted use pesticide.*

Restricted use pesticide — A pesticide that has been classified, under provisions of FIFRA (Amended), for use only by an appropriately certified applicator; a limited use pesticide that is applied only by qualified personnel, according to the law.

Restrictions — Limitations.

Rhizome — A root-like underground stem.

Rodent — Any animal of the order *Rodentia.* Examples: mice, rats, squirrels, gophers, woodchucks.

Rodenticide — A pesticide used to control rodents.

RPM — Revolutions per minute. A measurement of the speed at which something spins (turns).

Runaway pests — Any pest organisms which enter a new territory where they have no natural enemies, and therefore reproduce with little interference, resulting in a large population which can overrun an area.

Runoff — The sprayed liquid which does not remain on the plant. See *Point of drip.*

S

Safener — A chemical added to a pesticide to keep it from injuring plants.

Saprophyte — An organism that lives on dead or decaying organic matter.

Saprophytic — Living off of dead or decaying organic matter.

Seed protectant — A chemical applied to seed before planting to protect seeds and new seedlings from diseases and insects.

Selective pesticide — A pesticide which is more toxic to some types of plants or animals than to others. Usually used to describe a particular type of pesticide (e.g., "selective herbicide"). Sometimes known as *Specific pesticide.* Example: a slective herbicide might kill crabgrass in a cornfield but would not injure the corn.

Sensitive	Easily injured or affected by; susceptible to pesticidal effects at low dosage. Example: many broadleaved plants are sensitive to 2,4-D.
Sensitive areas	Locations where pesticide applications could cause great harm; applications in sensitive areas should be done with extreme care and caution. Examples: streams, ponds, houses, barns, parks, etc.
Shock	The severe reaction of the human body to a serious injury; can result in death if not treated (even if the actual injury was not a fatal one).
Short-term pesticide	When a pesticide breaks down almost immediately after application into non-toxic by-products. Same as *Non-persistent.*
Sidedress	A pesticide application along the side of a crop row.
Signal words and symbol	Words which must appear on pesticide labels, in accordance with FIFRA (Amended), to show how toxic the pesticide is. The signal words are: "Danger-Poison" (for highly toxic), "Warning" (for moderately toxic), and "Caution" (for low-order toxicity). The symbol of the skull and cross bones must appear on the labels of highly toxic pesticides (along with the words "Danger-Poison").
Sign	Some evidence of exposure to a dangerous pesticide; an outward signal of a disease or poisoning in a plant or animal, including people. Compare to *Sympton.*
Silvicide	A pesticide used to control unwanted brush and trees.
Site	An area, location, building, structure, plant, animal, or other organism to be treated with a pesticide to protect it from or to reach and control the target pest.
Slimicide	A pesticide used to prevent slimy growths.
Slurry	A thick suspension of a pesticide made from a wettable powder and water. See *Wettable powder.*
Soil application	Putting a pesticide in or on the soil instead of applying it directly to vegetables.
Soil fumigant	A pesticide used to control pests in the soil; when added to the soil, it takes the form of a gas or vapor. Since it can evaporate quickly, it is often used with some kind of cover (for example, a plastic sheet spread over the ground), which traps the gas in the soil until the pest is controlled.
Soil incorporation	The mixing of a pesticide into the soil by mechanical means; usually consists of a pesticide application to the soil followed by some sort of tillage. Same as *Incorporate into soil.*
Soil injection	The mechanical placement of a pesticide below ground level into the soil; usually the pesticide is a liquid which changes into a gas. Example: forcing a pesticide into the ground through a tube. Also a method of disposal of pesticides by putting them within the plow layer of soil by usual tillage practices.
Soil sterilant	A chemical that prevents the growth of all plants and animals in the soil; depending on the chemical, soil sterilization may be temporary or long-term.
Soluble	Will dissolve in a liquid.
Soluble powder (SP)	A dry (powder) preparation which contains a fairly high concentration (15% – 95%) of active ingredient that dissolves in water (or another liquid) and forms a solution so that it can be applied.
Solution	The mixture of one or more substances into another substance (usually a liquid) in which all ingredients are completely dissolved without their chemical characteristics changing; this mixture will not settle out or separate in normal use. Example: sugar dissolved in water.

Solvent	A liquid which will dissolve one or more substances to form a solution. Example: water is the solvent when it dissolves sugar.
Space spray	A pesticide which is applied in the form of tiny droplets which fill the air and destroy insects and other pests, either inside or out-of-doors.
Species	A group of living organisms called by the same common name because they are very nearly alike and can interbreed successfully.
Specific category	Any one of the pesticide use categories designated by FIFRA or by state regulations; a special area (such as Forest Pest Control or Aquatic Pest Control) requiring state certification for use of restricted materials by commercial applicators.
Specific pesticide	Same as *Selective pesticide.*
Spiders	Tiny animals closely related to insects; they have eight jointed legs, two body regions, no antennae (feelers), and no wings. Spiders are often grouped with mites and ticks.
Spillage	Any escape, leakage, dripping, or running over of a pesticide. (Note: Spillage should be cleaned up immediately!)
Spore	An inactive form of a micro-organism that is capable of becoming active again.
Spot treatment	A pesticide application directed at a small area, such as at specific plants. Opposite of a general application.
Spray drift	See *Drift.*
Spreader	An adjuvant which increases the area that a given volume of liquid will cover on a solid surface (such as a leaf).
Stage of development	A defined period of growth; usually refers to an insect. An insect goes through many changes in its growth from an egg to an adult; each such change is a stage of development.
Sticker	An adjuvant which increases the *Adherence* of a pesticide.
Stolon	An above-ground stem that produces roots.
Stomach poison	A pesticide which kills an animal when eaten or swallowed.
Structural pests	Any animal or organism that can damage houses, barns, and other structures. Examples: termites, carpenter ants, insects and rodents.
Subacute toxicity	How poisonous a pesticide is to an animal or person after repeated doses (long-term exposure).
Summer annuals	Plants which germinate in the spring, do most of their growing in the summer, produce flowers or seeds, and then die in the fall.
Supplement	Any substance added to a pesticide to improve its performance. Same as *Adjuvant.*
Surface active agent	An adjuvant which reduces surface tension between two different substances (such as water and oil). (Note: Most *Adjuvants* may be considered surface active agents.) Also known as *Surfactant.*
Surface spray	A pesticide which is sprayed evenly over the entire outside of the object to be protected.
Surface water	Water which is located above ground. Examples: ponds, lakes, streams, rivers, etc.
Surfactant	An adjuvant which improves the emulsifying, dispersing, spreading, and wetting properties of a pesticide. Same as *Surface active agent.*
Susceptibility	The degree to which an organism can be injured or affected by a pesticide at a known dosage (or exposure).
Susceptible	Capable of being injured, diseased, or poisoned by a pesticide; not immune.
Susceptible species	A plant or animal that is poisoned by moderate amounts of a pesticide.

Suspended — A pesticide use that is no longer legal and the remaining stocks cannot be used. (Note: This order is more severe than *Cancelled*.) Also, describes particles that are dispersed (or held) in a liquid.

Suspension — A pesticide formulation in which finely divided solid particles of an active ingredient are mixed (dispersed) in a liquid.

Swath — The width of ground covered by a sprayer when it moves across a field or other treated area.

Symptom — A feeling of being sick; a warning that something is wrong; an indication or feeling of poisoning or disease in a person, other animal, or plant. This information is used to figure out what pesticide or pest is causing the injury, damage, or disease. Compare to *Sign*.

Synergistic — When the combined action of two or more pesticides is greater than the sum of their activity when used alone.

Synthetic organic pesticides — Man-made pesticides which contain carbon, hydrogen, and other elements.

Systemic — A pesticide that is taken up by one part of a plant or animal and moved to another section where it acts against a pest; a pesticide distributed within a plant rather than applied to the plant's surface. Example: a systemic insecticide can be applied to the soil, be taken up by a plant's roots, move into the leaves, and then control insects when they feed on the leaves.

T

Take internally — To eat or swallow; to take by mouth into the digestive system.

Target — An area, building, animal, plant, or pest which is to be treated with a pesticide.

Target pest — The pest at which a pesticide application or other control method is directed.

Technical material — The pesticide (active ingredient) as it is manufactured by a chemical company before formulation.

Teratogenesis — The malformation of a fetus, with structural abnormalities being present at birth or becoming evident shortly after birth.

Test animals — Laboratory animals exposed to pesticides so that toxicity and hazards can be determined. Examples: rats, mice, rabbits, fish, birds.

Thermal — Of, about, or related to heat.

Ticks — Tiny animals closely related to insects; they have eight jointed legs, two body regions, no antennae (feelers), and no wings. They are blood-sucking organisms and are often found on dogs, cows, or other wild animals. Ticks are often grouped with mites and spiders.

Time interval — The period of time that is required between the final pesticide application and harvesting; the time interval ensures that the legal residue tolerance will not be exceeded.

Tolerance — The amount (expressed in ppm) of pesticide that may legally and safely remain in or on any raw farm products at the time of sale (if the food or feed or plant or animal is to be eaten by livestock or people). Also, the ability of an organism to withstand unfavorable conditions (such as pest attacks, extreme weather, or pesticides).

Tolerant — Not susceptible to (injured by) a pesticide application. Example: grass would be considered tolerant if an application of 2,4-D (an herbicide) controlled broadleaved weeds without killing the grass. Same as *Resistant*.

Topical application — A pesticide that is applied from above, usually to the top or upper surface of a plant.

Toxic — Poisonous; able to cause injury, by contact or systemic action, to plants and animals, including people.

Toxicant	Poison; an agent capable of being toxic.
Toxicity	How poisonous a pesticide is to an organism; the ability of a pesticide to produce injury. *Test animals* are used to establish *dermal, inhalation,* and *oral* toxicities.
Toxin	A poison produced by a plant or animal.
Trade name	Same as *Brand name.*
Translocated pesticide	A pesticide that moves within a plant or animal after it has entered by some path. *Systemic* pesticides are translocated.
Transport	To carry from one place to another, usually in a truck. Example: you transport pesticides when you take them from a dealer to the place of application.
Treated area	A house, barn, field, forest, garden, greenhouse, or other place where a pesticide application has been made.

U

Ultra low volume	A spray application of a pesticide that is almost pure active ingredient (technical material); it is sprayed in extremely small amounts over a large area (usually only a few ounces per acre and not more than ½ gallon per acre).
ULV	*Ultra-low volume.*
Underground water	Water and waterways which are below the soil surface; this is where wells get their water.
Uniform coverage	The even application of a pesticide over an entire area, plant, or animal.
USDA	United States Department of Agriculture.

V

Vapor	Gas, steam, mist, fog, fume, or smoke.
Vapor drift	See *Drift.*
Vaporization	Process of becoming a gas.
Vaporize	To evaporate; to form a gas and disappear into the air.
Vapor pressure	The property which determines how easily something evaporates. (Note: The lower the vapor pressure, the more easily a substance will evaporate.)
Vector	A carrier of a disease-producing organism (pathogen); an insect or other animal that transmits a pathogen. Examples: aphids, leafhoppers, and nematodes can transfer viruses from one host plant to another.
Vermin	Pests; usually rats, mice, or insects.
Vertebrate	An animal with a bony spinal column. Examples: mammals, fish, birds, snakes, frogs, toads.
Virus	A pathogen (disease-producing organism) that needs living cells to grow and can cause disease in plants and animals, including people; it is too small to be seen with a normal microscope.
Viscosity	The thickness of liquids; the degree to which or the ease with which a liquid flows. (Note: Viscosity usually increases when temperature decreases.)
Volatile	When a substance (usually a liquid) evaporates at ordinary temperatures if exposed to the air.
Volatility	How quickly and easily a liquid or solid evaporates at ordinary temperatures when exposed to the air.
Vomitus	What comes up when you throw up; matter which is vomited.

W

Waiting period — Same as *Time interval.*

"Warning" — A signal word used on pesticide labels that lets the user know the pesticide is moderately toxic. (Toxicity Category II, as defined by *FIFRA (Amended).*

Weathering — The wearing away of pesticides from the surfaces they were applied to because of wind, rain, snow, ice, and heat.

Weed — A plant growing where it is not wanted.

Weed control — Eradication, inhibition, or limitation of weeds, weed growth, or weed infestations; actions taken to prevent weeds from interfering with crop profitability or the efficiency of other operations.

Weed eradication — Total removal of a weed infestation from an area; the elimination of all live plants, plant parts, and seeds of weeds.

Wettable powder (WP or W) — A dry (powder) preparation that is mixed with water to form a suspension which is used for spraying. Unlike a *Soluble powder*, it does not dissolve in water, therefore formulation requires that a slurry be made and added to the partially-filled tank and that the tank then be filled up. (Note: If wettable powders are just dumped into the tank, it may result in a lumpy formulation which can clog nozzles and result in improper application.)

Wetting agent — An adjuvant which reduces surface tension and allows a pesticide to spread out and more evenly coat a surface; it decreases the rolling and running off of a pesticide.

Wide range — The ability of a pesticide to kill many different types of pests. See *Broad spectrum and Non-selective pesticide.*

Winter annuals — Plants which germinate in the fall or winter, do most of their growing in the spring, produce flower and seeds, and then die by early summer.